EVALUATION OF MICHIGAN'S LOW-LEVEL RADIOACTIVE WASTE ISOLATION FACILITY SITING CRITERIA

(A Science Report to Governor John Engler)

Prepared by
Michigan Environmental Science Board
Low-Level Radioactive Waste Panel

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JUNE 1996

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Michigan Environmental Science Board

The Michigan Environmental Science Board (MESB) was created by Governor John Engler by Executive Order 1992-19 on August 6, 1992. The MESB is charged with advising the Governor, the Natural Resources Commission, the Michigan Department of Natural Resources and other state agencies, as directed by the Governor, on matters affecting the protection and management of Michigan's environment and natural resources. The MESB consists of nine members and an executive director, appointed by the Governor, who have expertise in one or more of the following areas: engineering, ecological sciences, economics, chemistry, physics, biological sciences, human medicine, statistics, risk assessment, geology and other disciplines as necessary. Upon the request of the Governor to review a particular issue, a panel, consisting of MESB members with relevant expertise, is convened to evaluate and provide recommendations on the issue. The MESB is neither a state policy body nor an advocate for or against any particular environmental or public health concern.

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Evaluation of Michigan's
Low-Level Radioactive Waste Isolation Facility Siting Criteria

FINDINGS AND CONCLUSIONS

Under federal law, Michigan is responsible for providing disposal capacity for low-level radioactive waste (LLRW) generated within its borders. In 1987, the state passed the Michigan Low-Level Radioactive Waste Act (Pubic Act 204) which established a set of minimum criteria for the siting of a LLRW isolation facility. Using these criteria along with non-statutory criteria, the state unsuccessfully attempted from 1989 through 1993 to locate an area where the highly restrictive criteria would allow a LLRW isolation facility to be sited. In November 1990, the state's access to outstate LLRW facilities was terminated forcing its generators (hospitals, universities, nuclear power plants, industries and governmental facilities) to store their LLRW on-site. Although the state subsequently regained access to outstate disposal of its LLRW (mid-1995), the state's inability to site a LLRW facility has continued.

On July 26, 1995, the Michigan Environmental Science Board (MESB) was charged by Governor John Engler to evaluate the scientific basis and utility of Michigan's LLRW isolation facility siting criteria. On September 20, 1995, a LLRW Panel (Panel), composed of four MESB members and three guest scientists with expertise in radiation, nuclear medicine and health physics, was convened to begin the investigation. The investigation consisted of the accumulation and evaluation of peer-reviewed and some non-peer-reviewed literature and data on the subject. In addition, verbal and written testimony from LLRW management and disposal industry representatives, state and federal regulatory agencies, and concerned citizens were considered. Major findings and conclusions of the Panel are summarized below.

♦ Based on a review the state's geology and environment and an evaluation of the federal LLRW facility siting regulations and associated guidance documents, the Panel concludes that federal LLRW regulations, guidelines and standards for performance assessment studies should be sufficiently comprehensive to recognize, evaluate and protect the highly variable geological and environmental conditions found in Michigan. The Panel concurs with and recommends the interpretation and implementation of the federal LLRW regulations and associated federal guidance documents (NUREGs, Federal Guides and Branch Technical Position papers), as they pertain to the protection of resources and wishes to emphasize that in the case of Michigan, this includes minimizing impact to special attributes such as the Great Lakes and groundwater resources.

♦ Currently, a total of 32 criteria dictate the requirements for siting a LLRW facility in Michigan. Of the 32 criteria, 18 are required under Public Act 204 of 1987, and 14 were

proposed by the state's Siting Criteria Advisory Committee. The Panel reviewed the state's LLRW facility statutory and non-statutory siting criteria in terms of their being either adequately addressed in the federal LLRW standards and/or incorporating provisions which have no methodological basis for determination. Based on that review, the Panel concludes that all of Michigan's LLRW statutory criteria and all but one non-statutory criteria are either adequately addressed by the federal LLRW isolation facility siting criteria, standards and guidelines and/or contain arbitrary numerical restrictions without a methodological basis for determination. Consequently, these state statutory and non-statutory criteria are considered to be unwarranted. A single non-statutory state criterion, Criterion VIII-B (which states that if all other criteria are met, then preference should be given to areas near communities desiring the facility), was not found to be unwarranted since no reasonably similar federal provision could be found during the Panel's review.

♦ Ensuring that the levels of radiation exposure to the public, workers and potential intruders from a LLRW facility do not exceed public health and safety standards is a function of facility design and construction, limiting (by on-going assessment) the types and amounts of radioactive materials which may be accepted into the facility, proper and consistent management, institutional controls, and, ultimately, properly designed and operating environmental barriers. Based on the Panel's review of federal LLRW regulations, guidelines and performance standards, and assuming that the federal siting, design, operation, closure and postclosure standards and all performance standards would be adhered to, it is the Panel's conclusion that an engineered, centralized LLRW isolation facility could be sited and operated in Michigan without posing dangerous levels of radioactive risk to public health and safety or the environment.

♦ Under completely uncontrolled conditions, LLRW wastes have the potential for producing adverse effects in humans and the environment. However, considerable control is exerted over the environmental and occupational sources and avenues of potential radiation exposure by the federal LLRW regulations and guidelines in order to minimize as much as possible both the dose and length of exposure. Based on the Panel's evaluation of the environmental and human protective measures afforded by the federal LLRW regulations and guidelines, and assuming that the federal regulations and guidelines are closely adhered to and monitored, the Panel concludes that the risks of locating and operating an engineered, centralized LLRW isolation facility would be minimal.

♦ The Panel evaluated the advantages and disadvantages of temporarily storing LLRW on-site at the various LLRW generator locations throughout the state versus the disposal of such waste at an engineered, centralized LLRW isolation facility. The Panel's findings include that: (1) Michigan LLRW generators do not have the facilities or space to store any significant volume of LLRW for an extended period of time, and the

expectation of secure, long term (on the order of 500 years) storage of LLRW at the numerous generator sites is neither practical nor realistic when compared to disposal at a single site specifically designed and regulated to securely isolate LLRW; (2) the federal government currently can only minimally regulate generator storage of LLRW through guidelines rather than through promulgated, and therefore, more readily enforceable regulations; (3) the LLRW waste streams from Michigan generators are highly diverse and variable in volume and radioactivity and would represent a wide variety of employed local storage options, waste reduction techniques and practices, and management decisions which would be difficult to uniformly monitor and control; (4) the management and maintenance of long term secure LLRW storage facilities at the generator sites would require a greater number and different and more diverse level of staff expertise than currently exists at the generator sites; and (5) enlarging the role of the LLRW generators to also provide indefinite, temporary storage of LLRW represents only a interim rather than a permanent solution to the disposal of LLRW. Based on the above findings, the Panel concludes that the construction of an engineered, centralized LLRW facility would clearly provide important measures of security missing at present and an economy of scale by combining the supervision and monitoring of the present decentralized and diverse temporary storage facilities.

EVALUATION OF MICHIGAN'S LOW-LEVEL

RADIOACTIVE WASTE ISOLATION FACILITY

SITING CRITERIA

(A Science Report to Governor John Engler)

INTRODUCTION

Governor's Charge to the Michigan Environmental Science Board

The Michigan Environmental Science Board (MESB) was created by Governor John Engler by Executive Order 1992-19 on August 6, 1992. The MESB is charged with advising the Governor, the Natural Resources Commission, the Michigan Department of Natural Resources and other state agencies, as directed by the Governor, on matters affecting the protection and management of Michigan's environment and natural resources. The MESB consists of nine members and an executive director, appointed by the Governor, who have expertise in one or more of the following areas: engineering, ecological sciences, economics, chemistry, physics, biological sciences, human medicine, statistics, risk assessment, geology and other disciplines as necessary. Upon the request of the Governor to review a particular issue, a panel is convened to evaluate and provide recommendations on the issue.

On July 26, 1995, the MESB was charged by Governor Engler (Engler, 1995) to evaluate the scientific basis and utility of Michigan's siting criteria for low-level radioactive waste isolation facilities (see Appendix 1). On September 20, 1995, a Low-Level Radioactive Waste Panel (Panel), composed of four MESB members and three guest scientists with expertise in radiation, nuclear medicine and health physics, was convened to begin the investigation. The investigation consisted of the accumulation and evaluation of peer-reviewed and some non-peer-reviewed literature and data on the subject. In addition, verbal and written testimony from low-level radioactive waste management and disposal industry representatives, state and federal regulatory agencies, and concerned citizens were considered at four meetings (Harrison, 1996; 1995a; 1995b; 1995c). The report was prepared by the Panel with each individual assigned a specific topic or topics to address. The investigation lasted for a period of nine months.

The report addresses five directives from the Governor:

1. Evaluate whether Michigan's environment and/or geology pose unusual or unique conditions that would not be fully recognized, evaluated and protected under federal low-level radioactive waste (LLRW) siting regulations contained in 10CFR61 and the Nuclear Regulatory Commission's standards for performance-assessment studies.

2. Given the MESB's assessment of the protections afforded by federal siting and performance standards, and its review of any unique environmental conditions found in Michigan, determine if any of Michigan's statutory siting criteria are unwarranted.

3. In the judgment of the MESB, can an engineered LLRW isolation facility be located in Michigan without posing dangerous levels of radioactive risk to public health and safety and/or the environment.

4. Evaluate the relative risks associated with locating a centralized LLRW isolation facility in Michigan. In conducting this evaluation, consider the discussion on relative risk of LLRW contained in the Michigan Department of Natural Resources' July 1992 report entitled, *Michigan's Environmental and Relative Risk*.

5. Consider the relative risk of developing an engineered, centralized waste isolation facility with the risk of doing nothing; i.e., continuing to store LLRW at the approximately 50 existing locations.

Low-Level Radioactive Wastes

Title 10, Part 61 of the Code of Federal Regulations (10CFR61; OFR, 1995c) broadly defines LLRW as radioactive material that is not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or by-product materials as defined in Section 11e(2) of the Atomic Energy Act of 1954. The Code also provides a description of the types of waste which are allowable for a LLRW isolation site and a classification of the waste (Types A, B and C) based on concentration, isotope half-lives and types and activity.

Class A LLRWs include radioactive materials which have the lowest concentrations of long- and/or short-lived radionuclides and decay to a level which no longer pose a hazard within 100 years. Absent stabilization, Class A wastes would be segregated from Classes B and C in LLRW isolation facilities. Class B LLRWs include radioactive materials that have intermediate concentrations of long- and/or short-lived radionuclides and take between 100 and 300 years to decay to a level which no longer pose a hazard. Class B wastes must be stabilized before disposal. Class C LLRWs include radioactive materials with the highest concentrations of long- and/or short-lived radionuclides. Most Class C wastes decay to levels which no longer pose a hazard within 500 years. Class C wastes must meet the stability requirements of Class B wastes plus additional protective measures against inadvertent intruders for placement into LLRW isolation facilities (OFR, 1995c). Examples of Class A, B and C LLRW can include anything from test tubes, hypodermic needles and animal carcasses to contaminated rags, rubber gloves, clothing, tools, decontamination resins and solutions from nuclear power plants and parts of nuclear power plants other than the core fuel rods or other highly active, long-lived radionuclide-contaminated components (Public Sector Consultants, 1995; MDC, 1995; USNRC, 1989b).

Background and History of Michigan's Low-Level Radioactive Waste Isolation Facility Siting Efforts

In 1946 the federal government passed the Atomic Energy Act creating the Atomic Energy Commission (AEC). Among its responsibilities, the AEC was charged with the regulation of LLRW disposal. During the period between 1946 and 1961, the primary disposal method for LLRW was shallow land burial on federal lands. By 1962, the AEC began to accept license applications from private companies for the operation of LLRW

sites. Also introduced during this time was a program which allowed qualifying states to exercise regulatory authority over LLRW isolation facilities (Public Sector Consultants, 1995).

Between 1962 and 1979, six LLRW isolation sites had been opened and three of the six closed due to environmental contamination problems. The closures placed additional burden on the three remaining sites to accept all the nation's LLRW. Due in part to this pressure and a specific request by the National Council of Governors (Nagle, 1996), the federal government passed in 1980 and 1985 the Low-Level Radioactive Waste Policy Act and Policy Amendment Act, respectively. These Acts required each state to provide for, either by itself or in cooperation with other states, the disposal of LLRW generated within its borders. The laws also encouraged the creation of interstate compacts to manage the waste (Public Sector Consultants, 1995).

In 1982, Michigan joined the Midwest Interstate Low-Level Radioactive Waste Compact (Compact), along with the states of Indiana, Iowa, Missouri, Minnesota, Ohio and Wisconsin. Due to the volume of the LLRW generated in the state, Michigan was chosen in 1987 to site, develop and operate the first LLRW isolation facility. The Michigan siting effort began with the passage of the Low-Level Radioactive Waste Authority Act (Public Act 204 of 1987) which established a site selection process and minimum statutory siting criteria. Following a 1989 statewide exclusionary screening study (Schultink *et al*., 1989), three large areas were selected out of 81 identified Michigan candidate areas as potentially suitable to host a LLRW isolation facility. All three sites were further evaluated by the state (MDC, 1990) and found to be incapable of meeting all of the state's statutory exclusionary siting criteria and all were eliminated from further consideration by mid-1990 (Public Sector Consultants, 1995; MDC, 1995). A subsequent evaluation was conducted in 1993 (Battelle Memorial Institute, 1993) to examine the remaining identified candidate areas in the state. The later study concluded that "*... The application of only a portion of the exclusionary criteria has eliminated virtually the entire state ... .*"

Due to Michigan's restrictive siting criteria and its resulting inability to site a facility, the three existing LLRW isolation facilities in Nevada, South Carolina and Washington terminated the state's access to their facilities in November 1990. Consequently, this forced Michigan's LLRW generators to store their LLRW on-site. In addition, the Compact revoked Michigan's membership in 1991.

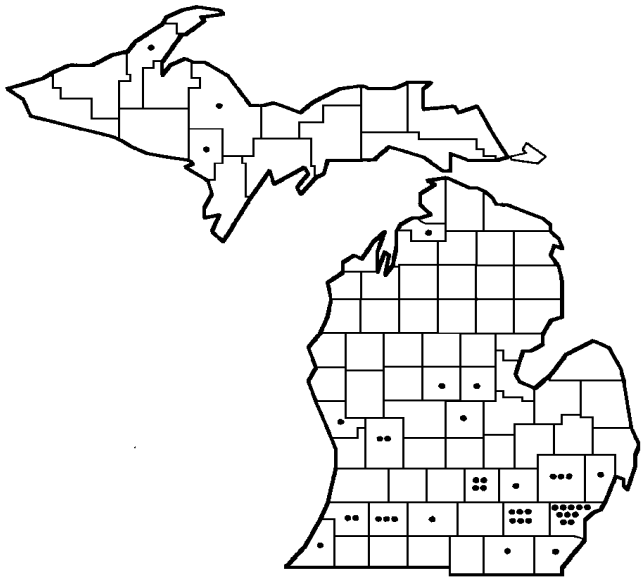
In 1994, Michigan passed Public Act 434 which called for the creation of two reports to address the state's waste management options and the development of a new siting process that uses a volunteer host community program plan. The required study addressing both issues was completed in September 1995 by the Board of Governors of the International Low-Level Radioactive Waste Research and Education Institute (Public Sector Consultants, 1995). In addition to outlining the framework for the requested volunteer plan, the study recommended that the current state siting criteria be removed in favor of federal standards. Also taking place in 1995 was South Carolina's lifting of its

ban and granting access to Michigan's LLRW generators to dispose of LLRW at the Barnwell facility.

Magnitude of Michigan's Low-Level Radioactive Waste Generation

During the period November 1990 to June 1995, Michigan was unable to ship its generated LLRW. This resulted in a build up of the waste at 44 locations throughout the state (see Figure 1). Table 1 presents the volume of waste in storage as of December 1994. Based on the survey, a total of 74,153 cubic feet (cu.ft.) of LLRW was found to have accumulated during the four years that Michigan was unable to ship its wastes. Of the total waste stored, Class A LLRW constituted the largest volume with 70,803 cu.ft. (95.5%). Classes C and B wastes comprised the second and third largest volumes (1,481 cu.ft., 2.0%; 1,365 cu.ft., 1.8%, respectively). A fourth category, mixed wastes (wastes that pose both a radiological and chemical hazard), comprised 0.7% of the total volume. In terms of final disposal and depending on the nature of the waste, mixed waste may be eventually treated as a Type A, B, or C waste if it can be treated to remove the chemical hazard. The survey also demonstrated that the majority of the waste (84%) was attributable to the nuclear power plants.

Figure 1. Low-Level Radioactive Waste Generators and Temporary Storage Sites in Michigan .[(a)]



(a) Modified from MDC, 1996.

Appendix 2 provides data on the activity and volume of LLRW which was shipped by Michigan generators to the Barnwell isolation facility in South Carolina in 1990 and 1995. A summary of these data are presented in Table 2. Based on these data, a total of 21

different generators shipped LLRW in 1990 and 1995. Of the 21 generators, only six (4 nuclear power plants, 1 industry and 1 hospital) shipped LLRW wastes in both 1990 and 1995. The remaining 15 generators shipped wastes either in 1990 (4 generators) or 1995 (11 generators) (Chem-Nuclear Systems, 1996a; 1996b). A total of 53 different isotopes was shipped by the Michigan generators both years, however the activity (in millicuries - mCi) associated with these isotopes was considerably greater in 1990 than 1995 (21,251,900.31 mCi versus 1,437,711.75 mCi, respectively). In terms of volume, Michigan generators shipped a total of 27,508.90 cu.ft. and 20,518.27 cu.ft. of LLRW (all waste classes) in 1990 and 1995, respectively. The largest shipments of waste came from the power plants in both years. With the exception of the university generators which did not ship wastes in 1995 to Barnwell, the lowest volume but highest concentration came from federal governmental facilities within the state (1995: 6.5 cu.ft. - 32,30.02 mCi/cu.ft.; 1990: 1.00 cu.ft. - 9,785.00 mCi/cu.ft.). Data on shipments from Michigan LLRW generators to other isolation facilities such as, for example, Envirocare in Utah are unavailable.

Table 1. Volume of Low-Level Radioactive Waste in Storage as of December 1994. [(a)]

Generator Type	Number of Generators	Volume (cu.ft.)					Percent of Waste
		Class A	Class B	Class C	Mixed	Total	
University	14	8,305	0	0	464	8,769	11.8
Government	2	146	0	0	0	146	0.2
Industry	13	1,938	0	105	40	2,083	2.8
Medical	11	1,085	0	0	0	1,085	1.5
Power Plants	4	59,329	1,365	1,376	0	62,070	83.5
Total	44	70,803	1,365	1,481	504	74,153	
(Percentage)		(95.5)	(1.8)	(2.0)	(0.7)	(100.0)	

(a) From MDC, 1995.

Total concentration (activity/unit volume) of shipped LLRW waste for all Michigan generators decreased from 1990 to 1995 (772.88 mCi/cu.ft. versus 70.03 mCi/cu.ft., respectively). For the federal government generator category, the higher level in total concentration in 1995 and the relatively high level of total concentration in 1990 are both attributable to the shipment of high activity hydrogen-3 (H-3 accounted for all but 0.64 mCi in 1995 and 0.01 mCi in 1990 of the total activity attributed to this category of generator - see Appendix 2).

As with the data presented in Table 1, care should also be taken with any interpretation of the waste disposal data contained in Table 2. These latter data reflect the activity of only 21 of the 44 known LLRW generators in the state and, of these, only six shipped wastes in both 1990 and 1995. Consequently, a reliable statistic on changes or trends in LLRW waste volume based on these data cannot be reasonably determined. Despite this lack of clear data, other studies (e.g., USNRC, 1996b; Stupka, Lewis and Langsted, 1993) have provided data which suggest for the period between 1980 and 1993 for both Michigan and the U.S. an overall trend of continued decrease in the annual amount of LLRW generation. According to Erickson (1996) and Public Sector Consultants (1995), two primary factors, lack of storage space (due the inability of the generators to ship wastes) and increased cost of disposal ($46.00/cu.ft. in 1988 to $326.00/cu.ft. in 1995), have been the major impetus for many of Michigan generators to employ LLRW waste reduction methods. Other possible factors for the observed decline, at least in Michigan, may have been the result of some medical and academic research facilities moving away from the use and/or reducing the volume of certain radioactive materials due to the lack of disposal access and the shifting by some industries of its operations to states where disposal was possible (Nagle, 1996). Regardless of the reason, this trend is expected to continue with a wide variety of waste treatment and reduction techniques being encouraged (Public Sector Consultants, 1995).

As part of the LLRW surveys conducted by the state during 1992 (MDC, 1993) and 1994 (MDC, 1995), the generators were requested to provide an estimate of the volume of LLRW they expected to generate for the period 1993 - 1995 (1992 survey) and for the period 1995 - 2000 (1994 survey). It was estimated by the responding generators that a total of 56,500 cu.ft. (or approximately 18,833 cu.ft./yr.) would be generated during the three year period (1992 survey) and a total of 89,720 cu.ft. (or approximately 17,944 cu.ft./yr.) would be generated during the five year period (1994 survey). While believed to be reasonable, some caution should be exercised with the use of the 1992 and 1994 estimates, since neither involved the full participation of all the Michigan LLRW generators and neither resulted from the use of any uniform estimation methodology.

The preceding LLRW actual and estimated waste generation and disposal information represents a steady state and does not account for any major increases. However, a significant increase LLRW volume must be anticipated to occur at the time of shutdown and decommissioning of any of the state's operating nuclear power plants. During the period 2001 through 2025, five of Michigan's nuclear power plants (Big Rock, Palisades, Cook #1, Cook #2 and Fermi II) are scheduled to be decommissioned (Strong, 1996). According to Public Sector Consultants (1995), just under 1,000,000 cu.ft. additional LLRW is anticipated to result. Historically, LLRW isolation facilities have focused on capacity for operational rather than decommissioning LLRW. While it can be expected that some of the high volume, low activity bulk LLRW from the decommissioning process may be able to be taken to isolation facilities which accept such bulk waste (Public Sector Consultants, 1995), the remainder of the wastes resulting from decommissioning will need to be taken to facilities already accepting annual operational LLRW wastes, thereby greatly taxing the capacity of such facilities.

Table 2. Summary of Michigan Low-Level Radioactive Waste Sent to Barnwell, South Carolina 1995 and 1990. [a]

Generator Type	Year	Number of Generators	Variety of Isotopes In Waste	Total Activity (mCi)	Total Volume (cu.ft.)	Total Concentration (mCi/cu.ft.)
University	1995	0	0	0.00	0.00	0.00
	1990	2	29	868.97	457.60	1.89
Federal Government	1995	2	3	210,002.11	6.50	32,308.02
	1990	1	2	9,785.01	1.00	9,785.00
Industry	1995	6	20	8,974.62	592.90	15.14
	1990	1	9	27.18	33.30	0.82
Medical	1995	5	11	256.33	82.87	3.09
	1990	2	7	117.94	120.30	0.98
Power Plants	1995	4	41	1,218,477.34	19,836.00	61.43
	1990	4	39	21,241,132.56	26,896.70	789.73
Total	1995	17[1]	53	1,437,710.40	20,518.27	70.07
	1990	10[1]	53	21,251,901.36	27,508.90	772.55

(a) Modified from Chem-Nuclear Systems, 1996a; 1996b.
(1) Included in the total are 6 generators which shipped LLRW wastes both years.

DIRECTIVE 1: Evaluate whether Michigan's environment and/or geology pose unusual or unique conditions that would not be fully recognized, evaluated and protected under federal low-level radioactive waste (LLRW) siting regulations contained in 10CFR61 and the Nuclear Regulatory Commission's standards for performance-assessment studies.

The purpose of this portion of the report is to evaluate the U.S. Nuclear Regulatory Commission's (USNRC) LLRW isolation facility siting regulations and performance standards contained in 10CFR61 (OFR, 1995c) in light of Michigan's environment and geology. The evaluation consists of a general overview of Michigan's geology and environment and a review of the pertinent sections of 10CFR61 (OFR, 1995c), and some of its more critical ancillary federal guidance documents.

Michigan's Geology and Environment

Michigan's geology and environment are highly diverse and variable. Several in-depth discussions of the state's geology and environment (physiography, soils, climate, vegetation, fauna, ecology, etc.) are available elsewhere (Dodge and Kavetsky, 1995; Nature Conservancy, 1994; Brewer, McPeek and Adams, 1991; Natural Features Inventory, 1989; Albert, Denton and Barnes, 1986; Voss, 1985; 1972; Baker, 1983; Barnes and Wagner, 1981; Eichenlaub, 1979; Dorr and Eschman, 1970; DeVos, 1964; 1962; Veatch, 1959; 1953; Hough, 1958; Billington, 1952; 1949; Robertson, 1940; Walpole, 1926; Kenoyer, 1924a; 1924b; Yuncher, 1921; Thompson, 1921; Darlington, 1920; Beal, 1904).

Most of Michigan is covered with glacial deposits over bedrock. Crystalline bedrock characterizes the western half of the upper peninsula. The remainder of the upper peninsula, as well as the lower peninsula, is characterized by variable types of sedimentary bedrock. The sedimentary formations in the lower peninsula and portions of the eastern upper peninsula form a geologic structure, an oblate bowl, called the Michigan Basin. Michigan is characterized by low seismicity. Events that shake ground in Michigan are as likely to be from within the state as they are from outside the state.

Bedrock formations are overlain by glacial deposits, with compositions ranging from gravel to clay and depths from inches to over 200 feet. Although the composition of the glacial deposits is highly variable across the state, large areas of these deposits, such as in the Saginaw Bay watershed, near the bay, are clay rich (Dorr and Eschman, 1970).

As a result of the last glaciation, Michigan was left with a diverse physiography ranging from level, low-lying lake border plains characteristic of much of the lower peninsula from the thumb southward, to the western upper peninsula with its mountain ranges (Albert, Denton and Barnes, 1986). Interspersed throughout the state are over 36,000 miles of rivers and streams nearly all of which drain into the Great Lakes. The Saginaw River and Grand River watersheds are the largest in the state. In addition, there are

6,500 known inland lakes (10 acres or larger) in the state (Institute of Water Research, 1987). The majority of the state is bordered by four of the five Great Lakes (Michigan, Erie, Huron, and Superior).

Michigan contains a large groundwater resource and much of the state's population and industry are dependent upon groundwater for fresh water. Groundwater occurs in fractures of the crystalline bedrock and in pores in the sedimentary bedrock. Groundwater flow within the state is largely toward the Great Lakes. From a recent study by the U.S. Geological Survey (Hoagland, 1996; Mandle and Westjohn, 1989), it appears that a significant portion of the recharge water is discharged directly to streams as opposed to entering the deeper groundwater system. However, more work needs to be done on this to fully understand the nature of groundwater flow throughout the state. The spatial variability of the types of bedrock and glacial deposits affects the quality and quantity of usable groundwater. Most of Michigan's groundwater is near the surface.

The fresh groundwater overlies ancient highly concentrated fluids. The nature of the concentrated fluids and their interaction with the near-surface fresh water is not as well known for the upper peninsula as it is for the lower peninsula. In some areas of the state, the concentrated fluid enters near-surface environments, such as in the Saginaw Bay area. Flow of this saline water is mostly via diffusion. However, saline springs have been known to exist in many areas around the state.

Michigan's climate may be broadly characterized as being dominated by three weather patterns. The two most dominant patterns are those that originate from west to north and from west to south, influencing weather in northern Michigan and southern Michigan, respectively. The approximate boundary, or tension line, between these areas runs along an east-west line at about the latitude of Bay City. In general, the southern lower peninsula is warmer with a long frost-free season, has more rain in the springtime, less rain in the fall, and more thunderstorms, tornadoes, hail and freezing rain than the north. The climate of the northern lower peninsula and eastern upper peninsula tends to be cooler with a shorter frost-free period, greater snowfall and influenced more by the presence of the bordering Great Lakes. A third, less extensive, weather pattern occurs in the western most portion of the upper peninsula. Due in part to the generally higher elevations and more northerly location, cooler temperatures, severe thunderstorms and high winds are common (McCann, 1991; Albert, Denton and Barnes, 1986; Niedringhaus, 1966).

Despite the fact that the same factors have influenced Michigan's climate for thousands of years, the state's climate has fluctuated. The change from glacial conditions occurred about 11,300 years ago, when warm dry Pacific air masses became more frequent. Warm air masses dominated from 9,500 to 4,700 years ago. The tendency since then has been toward cooler and wetter conditions with a brief warming period from 1200 to 1400 A.D. Cooler temperatures and greater precipitation dominated again from around 1550 to 1850. From the period 1890 to the 1930's, summer temperatures

increased and precipitation decreased. Winter temperatures continued to rise into the 1950s and there was a wet, cool trend from the late 1950s into the 1970s. The 1980s and 1990s have tended to have record warm temperatures (McCann,1991; Eichenlaub, 1979).

Present-day vegetation of Michigan is a result of the geology, soils, past and present climates, post-Pleistocene species migration patterns, and human alteration of lands and plant communities. Eight general vegetational communities are recognized (McCann, 1991) for the state:

(1) Boreal and Wet Coniferous Forest (balsam fir, spruces, tamarack and white cedar), occurring mostly in the central and eastern upper peninsula;
(2) Dry Coniferous Forest (pines), occurring throughout the upper peninsula and northern lower peninsula;
(3) Disturbed Northern Forest (aspen, paper birch) occurring mostly in northern lower peninsula;
(4) Mesic Mixed Forest (sugar maple, yellow birch, hemlock), occurring in the western upper and western northern peninsulas;
(5) Dry Deciduous Forest (oaks), occurring mostly in the mid and southern lower peninsula;
(6) Mesic Deciduous Forest (sugar maple, American beech) occurring in southern lower peninsula;
(7) Open Land (farms, open wetlands, barrens) occurring throughout the state but especially in mid and eastern southern lower peninsula; and
(8) Major Urban Areas.

Based on 1978 aerial photography, Michigan's land use/cover may be grouped (MDNR, 1990) into seven categories:

(1) Urban and Built Up Lands (residential areas, commercial and institutional facilities, industrial complexes, transportation corridors, utilities, cemeteries, etc.), comprising 6.26 percent of the state;
(2) Agricultural Lands (cropland, orchards, confined feeding areas, permanent pasture), comprising 29.33 percent of the state;
(3) Open Lands (non-forested land - either herbaceous or shrubland), comprising 8.05 percent of the state;
(4) Forest Lands (upland and lowland deciduous and coniferous forests), comprising 48.78 percent of the state;
(5) Water Bodies (rivers, lakes and reservoirs), comprising 2.25 percent of the state;
(6) Wetlands (wooded wetlands, shrub wetlands, aquatic beds, emergent wetlands and flats), comprising 5.20 percent of the state; and
(7) Barren Land (beaches, unvegetated sand dunes and exposed rock), comprising 0.14 percent of the state.

Michigan has a diversity of natural resources. Included among these are the state's commercial and non-commercial forests, fish and wildlife (game and non-game species), Great Lakes and associated sand dunes, inland lakes, rivers, streams and wetlands, groundwater, coal deposits, oil and natural gas deposits (occurring mostly in northern-central and western lower peninsula), ore deposits (e.g., iron and copper formations of the northwestern upper peninsula), and other mineral occurrences (e.g., some of the more common found locally including: calcite, chert, chlorite, epidote, feldspar, flint, goethite, gypsum, halite, hematite, hornblende, jasper, limonite, magnetite, mica, microcline, muscovite, olivine, orthoclase, petoskey stone, plagioclase, prehnite, quartz, and serpentine) (Dorr and Eschman, 1970).

Identification of Relevant Sections from 10CFR61

Seven sections within 10CFR61 (OFR, 1995c) were identified as the most relevant to the protection of Michigan's geology and environment. A brief overview of the requirements contained in each section is presented below.

Subpart A: General Provisions

Section 61.7(a) (Disposal Facility). This section indicates that the regulations contained in 10CFR61 (OFR, 1995c) are for land disposal only and not sea (large lake) or extraterrestrial disposal. Although the regulations are for any form of land disposal, they are specific for near-surface land disposal. Near-surface disposal is defined as being within 30 meters of the land surface, includes engineered facilities that are totally or partially above grade and must contain protective earthen covers. This section defines the buffer zone at the disposal site as the portion of a site controlled by the licensee that lies under and between the boundary of the disposal site and any disposal unit. Buffer zones represent controlled space where monitoring sites may be established. Further, it is stated that in choosing a disposal site, site characteristics should be considered in terms of an indefinite future and have an evaluation period of at least a 500 years.

Section 61.7(b) (Waste Classification and Near-Surface Disposal). This section contains provisions which address safety issues. The general population, as well as those individuals who work at the site during operations, must be protected from releases of radioactivity. The site must be designed to minimize access of water to the waste. This section indicates that there must be provisions to protect individuals from inadvertent intrusion into the waste containment areas. Time is highlighted as an issue. For example, institutional control of the site is required for up to 100 years. Such a time period permits disposal of Class A and B wastes at the site without special provisions for intrusion protection, since these classes of wastes contain radioisotopes that decay during the 100 year period to acceptable levels. On the other hand, for disposal of Class C wastes, barriers must be designed with an effective life of 500 years, after

which time the radioisotopes in this class of waste will have decayed to acceptable limits

Subpart B: Licenses

Section 61.13 (Technical Analyses). The section contains provisions that concern technical analyses which must be addressed by the licensee. To demonstrate that protection of the general population from releases of radioactive isotopes has been fully evaluated, the following pathways must be explored: air, soil, groundwater, surface water, plant uptake, and exhumation by burrowing animals. Analysis of the long term stability of the site must be based on active natural processes such as erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration, and surface drainage.

Subpart C: Performance Objectives

Section 61.41 (Protection of the General Population from Releases of Radioactivity). This section specifically addresses the levels of radioactivity that can be released to the environment. It states that radioactivity released to the general environment (groundwater, surface water, air, soil, plants, or animals) must not result in an annual dose exceeding an equivalent of 25 millirem (mrem) to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ.

Section 61.44 (Stability of the Disposal Site after Closure). This section addresses the long term stability of the site and indicates that the facility must be sited, designed, used, operated, and closed to achieve long term stability of the disposal site. In addition, it needs to be designed to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.

Subpart D: Technical Requirements

Section 61.50 (a) (Disposal Site Suitability Requirements for Land Disposal). This section specifies the minimum characteristics that a disposal site must have for suitability. It emphasizes long-term isolation. Key points include:

(1) The site shall be capable of being characterized, modeled, analyzed and monitored;
(2) The facility should be located so that projected population growth and future developments are not likely to affect ability of facility to meet performance objectives;
(3) Areas for the construction of the site must be avoided that have known natural resources;
(4) The site must be generally well drained and free of areas of flooding or frequent ponding;

(5) Waste disposal shall not take place in a 100 year flood plain, coastal high-hazard area or wetland;
(6) Upstream drainage areas must be minimized to decrease the amount of runoff which could erode or inundate waste disposal units;
(7) The site must provide sufficient depth to the water table that groundwater intrusion, perennial or otherwise, into the waste will not occur (An exception would be considered and disposal allowed below the water table if it can be conclusively shown that disposal site characteristics will result in molecular diffusion being the predominant means of radionuclide movement and that the rate of movement will result in the performance objectives of Subpart C being met. In no case will waste disposal be permitted in the zone of fluctuation of the water table);
(8) The hydrogeologic unit used for disposal shall not discharge groundwater to the surface within the disposal site;
(9) Areas must be avoided where tectonic processes, such as faulting, folding, seismic activity, or volcanism may occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives in Subpart C or may preclude defensible modeling and prediction of long-term impacts;
(10) Areas must be avoided where surface geologic processes such a mass wasting, erosion, slumping, landsliding, or weathering occur with such frequency and extent to significantly affect the performance objectives or may preclude defensible modeling and predication of long term impacts; and
(11) The disposal site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives.

Section 61.52 (Land Disposal Facility Operation and Disposal Site Closure). This section reiterates the concept of the buffer zone by stating that a buffer zone of land must be maintained between any buried wasted and the disposal site boundary and beneath the disposed waste. The buffer zone needs to be of adequate dimensions to carry out environmental monitoring activities.

Section 61.53 (Environmental Monitoring). This section defines what shall be monitored in the environment at the site. It states that the applicant will obtain information about the ecology, meteorology, climate, hydrology, geology, geochemistry, and seismology of the disposal site. For those characteristics that are subject to seasonal variation, the data must cover at least a 12 month period.

Federal Guidance Documents

Several ancillary documents to 10CFR61 (OFR, 1995c) have been developed by the USNRC to provide guidance to federal staff with the responsibility for interpretation of the federal LLRW regulations and for the review, evaluation and approval of

applications submitted for siting, construction, operation, monitoring, closure and postclosure of LLRW facilities. While none of these documents are specifically referenced in 10CFR61 (OFR, 1995c), they do provide to LLRW applicants implicit guidance, elaboration and clarification of the federal statutory LLRW requirements and establish the minimum criteria considered necessary by the USNRC to obtain its approval of a LLRW application (Thaggard, 1996; USNRC, 1994b). Tables 3 and 4 present a listing of two types of federal guidance documents (NUREGs and Regulatory Guides, respectively) considered by the USNRC as essential for use by applicants in the technical development of LLRW disposal facilities applications (USNRC, 1994b). Additional USNRC guidance documents include industry codes and standards, and branch technical positions. Branch technical positions and appendices present solutions and approaches that are acceptable to USNRC staff, but are not considered as the only possible solution or approach to addressing a particular LLRW disposal facility issue (USNRC, 1994b). A brief summary of six of the more important LLRW federal guidance documents is presented below.

NUREG 1388 - Environmental Monitoring of Low-Level Radioactive Waste Disposal Facility (Shum, Starmer and Young, 1989). This document provides guidance for the design of a program to environmentally monitor preoperational, operational and postoperational stages of a LLRW facility. The program consists of the collection of samples and the measurements of concentrations of radioactivity, radionuclides, direct radiation, chemical and other physical properties of specific media for the environment where the LLRW facility will be located. The purpose of the preoperational monitoring program is to provide site characterization information, demonstrate site suitability and acceptability, and obtain background baseline data. The purpose for the operational monitoring program is to demonstrate compliance with applicable environmental radiation standards and obtain data on critical pathways parameters to allow accurate evaluations of radiation doses to the general public. The purpose of the postoperational monitoring program is to demonstrate compliance with site-closure requirements and provide data to support long term impact evaluations.

NUREG 1300 - Environmental Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility (USNRC, 1987). Each applicant seeking a license for a LLRW disposal facility must prepare and submit an environmental report pursuant to requirements contained in 10CFR61 (OFR, 1995c) and 10CFR51 (OFR, 1995b). This document outlines the content and level of evaluation expected by the USNRC of the applicant in the preparation of a LLRW disposal environmental report. Specifically, the guidance document requires a description of the purpose and need for the project, description of the proposed project and alternatives considered, description of the affected environment (population distribution and characteristics, current and projected land use, meteorology and air quality, ambient radiation levels, surface water, groundwater, geology, ecology, and socio-economics and cultural resources), environmental consequences and mitigating actions, including radiological impacts and dose assessments to humans and other

biota, impacts of accidents; and relationships to local, state, regional and/or federal land use plans, policies and controls.

Table 3. Essential USNRC Guidance Documents (NUREGs) for the Siting, Design, Operation, Closure and Postclosure of Low-Level Radioactive Waste Disposal Facilities. [(a)]

NUREG 0696 - Functional Criteria for Emergency Response Facilities
NUREG 0868 - A Collection of Mathematical Models for Dispersion in Surface Water and Groundwater
NUREG 0902 - Site Suitability, Selection and Characterization
NUREG 1165 - Environmental Impacts of Postulated Accidents Involving Releases of Radioactive Materials to Groundwater
NUREG 1199, Revision 2 - Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility
NUREG 1200, Revision 3 - Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Facility
NUREG 1274 - Review Process for Low-Level Radioactive Waste Disposal License Application Under Low-Level Radioactive Waste Policy Amendments Act
NUREG 1300 - Environmental Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility
NUREG 1388 - Environmental Monitoring of Low-Level Radioactive Waste Disposal Facility
NUREG/CR 2700 - Parameters for Characterizing Sites for Disposal of Low-Level Radioactive Waste
NUREG/CR 2917 - Review of Ground-Water Flow and Transport Models in the Unsaturated Zone
NUREG/CR 3038 -Tests for Evaluating Sites for Disposal of Low-Level Radioactive Waste
NUREG/CR 3164 - Subsurface Monitoring Programs at Sites for Disposal of Low-Level Radioactive Waste
NUREG/CR 3332 - Radiological Assessment - A Textbook on Environmental Dose Analysis
NUREG/CR 3343 - Recommended Radiation Protection Practices for Low-Level Waste Disposal Sites
NUREG/CR 3756 - Seismic Hazard Characterization of the Eastern United States, Methodology and Interim Results for Ten Sites

(a) From USNRC, 1994b.

Table 4. Essential USNRC Guidance Documents (Regulatory Guides) for the Siting, Design, Operation, Closure and Postclosure of Low-Level Radioactive Waste Disposal Facilities. [(a)]

Regulatory Guide 1.23 - On-site Meteorological Programs (Safety Guide 23)
Regulatory Guide 1.28 - Quality Assurance Program Requirements (Design and Construction)
Regulatory Guide 1.59 - Design Basis Floods for Nuclear Power Plants
Regulatory Guide 1.94 - Quality Assurance Requirements for Installation, Inspection and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants
Regulatory Guide 1.109 - Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix 1
Regulatory Guide 1.132 - Site Investigations for Foundations of Nuclear Power Plants
Regulatory Guide 1.138 - Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants
Regulatory Guide 4.5 - Measurements of Radionuclides in the Environment, Sampling and Analysis of Plutonium in Soil
Regulatory Guide 4.13, Revision 1 - Performance, Testing and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications
Regulatory Guide 4.15, Revision 1 - Quality Assurance for Radiological Monitoring Programs (Normal Operations): Effluent Streams and the Environment
Regulatory Guide 4.18 - Standard Format and Content of Environmental Reports for Near-surface Disposal of Radioactive Wastes
Regulatory Guide 4.19 - Guidance for Selecting Sites for Near-Surface Disposal of Low- Level Radioactive Waste
Regulatory Guide 8.2 - Guide for Administrative Practices in Radiation Monitoring
Regulatory Guide 8.8 - Information Relevant to Ensuring that Occupational Exposure at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable
Regulatory Guide 8.10 - Operating Philosophy for Maintaining Occupational Radiation Exposure As Low As Is Reasonably Achievable
Regulatory Guide 8.21, Revision 1 - Health Physics Surveys for Byproduct Material at NRC Licensed Processing and Manufacturing Plants
Regulatory Guide 8.29 - Instructions Concerning Risks from Occupational Radiation Exposure
Regulatory Guide 8.34 - Monitoring Criteria and Methods to Calculate Occupational Radiation Doses
Regulatory Guide 8.36 - Radiation Doses to the Embryo/Fetus

(a) From USNRC, 1994b.

NUREG 1200 (Revision 3) - Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Facility (USNRC, 1994b). This document, along with NUREG 1199 (USNRC, 1991), describes in detail nearly 70 issue-related evaluations related to nuclear safety at proposed LLRW disposal facilities.

Each evaluation, singly or in combination, serves to address and satisfy one or more of the performance objectives of 10CFR61.41 - 61.44 and standards for the issuance of a license (10CFR61.23). Issues specifically addressed in NUREG 1200 include: (1) site characteristics including expected evaluations of geography, demography, future developments, site location and description, population distribution, meteorology and climatology, geology and seismology, geologic characterization, seismic investigation, surface water hydrology, groundwater characterization, geotechnical and geochemical characteristics, natural, geologic and water resources, biotic features and preoperational environmental monitoring; (2) facility design and construction guidance and expectations; (3) facility operations guidance including waste receipt, inspection handling, interim storage and disposal, and operational environmental monitoring and surveillance; (4) site closure plan and institutional controls; (5) expected safety assessments including accidents, possible radioactivity transfer mechanisms (groundwater, air and surface water), surface drainage and erosion protection, stability of slopes and settlement and subsidence; (6) expected occupational radiation protection measures in order to meet the requirements of 10CFR20 (OFR, 1995a); (7) conduct of operations and quality assurance during design, construction and operation; and (8) financial assurance and licensing conditions.

NUREG 1199 (Revision 2) - Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility (USNRC, 1991). This document details the necessary components required under 10CFR61 (OFR, 1995c) for a LLRW disposal facility application.

NUREG 0902 - Site Suitability, Selection and Characterization (Siefken *et al.*, 1982). This document provides information and interpretations regarding data needed to adequately address and/or describe: (1) site suitability requirements contained in 10CFR61.50 (OFR, 1995c), (2) site selection process as related to consideration of alternatives and (3) site characterization activities to be performed in order to develop the site-specific data needed to support a LLRW license application and environmental report.

Branch Technical Position on Performance Assessment for Low-Level Waste Disposal Facilities, Draft (USNRC, 1994a). This draft document provides LLRW license applicants, licensees and USNRC staff with an acceptable strategy and methodology for performing the technical analysis required to demonstrate compliance, in postclosure time frame, with the performance objectives governing radiological protection of the general public addressed in 10CFR61.41 (OFR, 1995c). The document provides general guidance on an acceptable performance assessment strategy that integrates site characterization and performance modeling and on implementing the USNRC performance assessment methodology. It is designed to augment the guidance provided in NUREGs 1199 and 1200 (USNRC, 1991; 1994b).

Conclusion

Based on the Panel's review of the state's geology and environment and its evaluation of the federal LLRW regulations and associated guidance documents, the Panel concludes that the federal LLRW regulations, guidelines and standards for performance assessment studies should be sufficiently comprehensive to recognize, evaluate and protect the highly variable geological and environmental conditions found in Michigan. The Panel concurs with and recommends the interpretation and implementation of the federal LLRW regulations and the associated federal guidance documents (NUREGs, Federal Guides and Branch Technical Position papers), as they pertain to the protection of resources and wishes to emphasize that in the case of Michigan, this includes minimizing impact to special attributes such as the Great Lakes and groundwater resources.

DIRECTIVE 2. Given the MESB's assessment of the protections afforded by federal siting and performance standards, and its review of any unique environmental conditions found in Michigan, determine if any of Michigan's statutory siting criteria are unwarranted.

During and since the development of the Michigan LLRW facility siting criteria, there have been several evaluations and comparisons made of the state's siting criteria (Bornhorst, 1995; Battelle Memorial Institute, 1993; MDC, 1991; 1989; 1988; Lehman & Associates, 1990; 1988; USNRC, 1988b; Rogers and Associates, 1988; Envirosphere Company, 1988). In order to make a determination regarding the utility of the Michigan LLRW siting criteria, the Panel consulted the above reviews of the Michigan siting criteria and comparisons between these and other state and federal regulations.

Currently, a total of 32 criteria dictate the requirements for siting a LLRW isolation facility in Michigan. Of the 32 criteria, 18 are required under Public Act 204 of 1987 and 14 were proposed by the state's Siting Criteria Advisory Committee. The criteria may be divided into two categories (1) exclusionary criteria that exclude an area from further consideration (20 criteria) and (2) favorable criteria that distinguish the relative suitability of those areas not excluded (12 criteria) (Battelle Memorial Institute, 1993; MDC, 1989).

Appendix 3 presents a summary comparison of Nuclear Regulatory Commission, Michigan and 12 other states' LLRW disposal facility siting regulations presented across eight categories (population, geological and flood hazards, hydrogeological factors, transportation, meteorology, environmental and resource factors, economic and social factors, and site size). In general, Michigan's regulations may be characterized as being either identical with or more restrictive than those of 10CFR61 (OFR, 1995c) in all eight siting categories. In terms of other states' regulations, no clear pattern is readily observed with some of Michigan's LLRW siting criteria being more restrictive in certain siting categories and less restrictive in others.

Michigan Low-Level Radioactive Waste Facility Statutory and Non-Statutory Siting Criteria

In July 1990, Lehman & Associates (1990) submitted a comprehensive report to the Midwest Interstate LLRW Commission. The purpose of the report was to evaluate Michigan's final LLRW facility siting criteria for their basis in Michigan law, compliance with the USNRC regulations, and technical reasonableness. In general, the Panel concurs with the evaluation conducted regarding the criteria by this firm. Using, in particular, the Lehman & Associates (1990) and Battelle Memorial Institute (1993) evaluations and the comparison presented in Appendix 3 as its basis, the Panel reviewed the following Michigan LLRW facility statutory and non-statutory siting criteria in terms of their being either adequately addressed in the federal LLRW standards and/or incorporating provisions which have no methodological basis for determination.

Criterion I-A. *Exclude areas within incorporated city limits as established on January 1, 1988.* In addition to the fact that a city limit boundary does not necessarily dictate a high population density, the concern for population density and projected population is adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 1199, 1200, and 1300 (USNRC, 1991; 1994b; 1987) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion I-B. *Exclude areas not sufficiently large enough to assure that an isolation distance of 3,000 feet (915 m) or more from the disposal unit and adjacent property lines is available.* In addition to the 3,000 feet value being an arbitrary number (i.e., no methodological basis for determination), buffer zones are adequately addressed in 10CFR61 (OFR, 1995c) and NUREGs 1199 and 1200 (USNRC, 1991; 1994b).

Criterion I-C. *Seek areas where projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the performance objectives of 10CFR61 Subpart C (10CFR61.50(a)(3)) and are not likely to significantly interfere with an environmental monitoring program.* The issues of population density and projected population and development are adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199; 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion II-A. *Exclude areas located one mile or less from a fault where tectonic movement has occurred within the last 10,000 years.* In addition to the fact that there is no evidence to indicate that this criterion has any significance in Michigan (Battelle Memorial Institute, 1993; Schultink *et al.*, 1989), this criterion is adequately addressed in NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987), NUREG/CR 3756 (Bernreuter *et al.*, 1984) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion II-B. *Exclude areas of significant earthquake intensity, defined as zones with a modified Mercalli index of VII or greater.* In addition to the questionable usefulness of basing the criterion on a seismic intensity value which has not occurred within Michigan's recorded history (MDC, 1989), the selection of tectonically stable sites is adequately addressed in NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987), NUREG/CR 3756 (Bernreuter *et al.*, 1984) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion II-C. *Exclude areas within the 500 year flood plain, including areas designated under 245 PA 1929 (Sections 323.1 to 323.13 of the Michigan Compiled Laws).* The 500-year flood plain criterion is more restrictive than 10CFR61 (OFR, 1995c). According to the USNRC in 1988, "... *The Commission considers 300 or 500 year flood plains to be unnecessarily restrictive and questions whether an adequate data base or standard methods of determining such flood plain exists. In addition to there being no rationale given to explain the need for more restrictive criteria, we questioned the ability to define a 500 year flood plain or a 500 years flood, given the*

limited amount of data available for most streams. …" (USNRC, 1988b). This criterion is adequately addressed in NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 1.59, 4.18, and 4.19 (USNRC, 1977; 1983; 1988a).

Criterion II-D. *Exclude areas where geological processes such as mass wasting, erosion, slumping, land-sliding or weathering precludes meeting the performance objectives in 10 CFR 61 Subpart C or precludes defensible modeling and prediction of the long term impact of such occurrences.* This criterion is adequately addressed in NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 1.132, 1.138, 1.59, 4.18, and 4.19 (USNRC, 1979; 1978; 1977; 1983; 1988a).

Criterion III-A. *Exclude areas where the water table associated with geologic deposits or formations is not sufficiently low to prevent the intrusion of groundwater into the disposal unit or bottom most portions of the leak detection system, if one should be included in the design.* This criterion is adequately addressed in NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987), NUREG/CR 2917 (Oster, 1982) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion III-B. *Exclude areas where there is not 6 or more meters (20 feet) of soil with a maximum hydraulic conductivity of 1.0 times 10 to the minus 6 centimeters per second at all points below and lateral to the disposal unit and bottom most portions of the leak detection system, if one should be included in the design, or areas where there is not greater than 6 meters of relatively impervious soil that provides equivalent environmental protection to the public health, safety, welfare, and the environment. The soil should extend laterally a sufficient distance to assure that it cannot be circumvented by ground water flow within 500 years*. This criterion is adequately addressed in NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987), NUREG/CR 2700 and 2917 (Lutton *et al.*, 1982; Oster, 1982) and Regulatory Guides 1.132, 1.138, 4.18, and 4.19 (USNRC, 1979; 1978; 1983; 1988a).

Criterion III-C. *Exclude areas where the average travel time of groundwater along any 100 foot flow path from the water table beneath the bottom of the disposal unit is less than approximately 100 years.* Hydrogeological conditions and restrictions are adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199, 1200, 1300, 2700, and 3164 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987; Lutton *et al.*, 1982) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion III-D. *Exclude areas where the average groundwater travel time from the water table beneath the bottom of the disposal unit to an aquifer is less than 500 years.* The 500 year value is unnecessarily restrictive since it does not assume any isolation of the waste as a result of the engineered barriers in the waste package, disposal facility or from flow in the unsaturated zone. In addition, hydrogeological conditions and restrictions are adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199,

1200, 1300, and 2700 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987; Lutton *et al.*, 1982), NUREG/CR 2917 (Oster, 1982) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion III-E. *Exclude areas located over a designated sole source aquifer.* Not locating a LLRW site over a known aquifer designated a sole source is reasonable; however, in the absence of any designated sole source aquifer within Michigan or a definition for such an aquifer, the criterion has no meaning (Battelle Memorial Institute, 1993). Hydrogeological conditions and restrictions are adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1165, 1199, 1200, 1300, and 2700 (Siefken *et al.*, 1982; USNRC, 1985; 1991; 1994b; 1987; Lutton *et al.*, 1982) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion III-F. *Exclude areas located where the hydrogeology beneath the site discharges groundwater to the surface within 3,000 feet (915 m) of the boundaries of the disposal unit.* In addition to the 3,000 foot value being arbitrary (i.e., no methodological basis for determination), hydrogeological conditions and restrictions are adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199, 1200, 1300, and 2700 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987; Lutton *et al.*, 1982) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion III-G. *Exclude areas not free of ponding or incapable of being drained in a manner that ensures the integrity of the disposal unit*. The criterion is adequately addressed in 10CFR61 (OFR, 1995c) and NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion III-H. *Exclude areas located within 10 miles of Lake Michigan, Lake Superior, Lake Huron, Lake Erie, Saint Mary's River, St. Clair River or Lake St. Clair. This criterion shall not apply to a site that is located at or adjacent to a nuclear power generating facility.* The value of 10 miles is an arbitrary number with no methodological basis for determination. Protection of surface waters is addressed in NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion III-I. *Seek areas with simple hydrologic systems that can be characterized, modeled, analyzed and monitored.* Hydrogeological conditions and restrictions are adequately address in 10CFR61 (OFR, 1995c), NUREGs 0902, 1165, 1199, 1200, 1300, and 2700 (Siefken *et al.*, 1982; USNRC, 1985; 1991; 1994b; 1987; Lutton *et al.*, 1982) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion III-J. *Seek areas that do not overlie aquifers that produce potable water.* Protection of potable water is adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1165, 1199, 1200, 1300, and 2700 (Siefken *et al.*, 1982; USNRC,

1985; 1991; 1994b; 1987; Lutton *et al.*, 1982) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion III-K. *Seek areas which do not include public water supply wells, well fields, high capacity production wells, and abandoned wells.* Hydrogeological conditions and restrictions are adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1165, 1199, 1200, 1300, and 2700 (Siefken *et al.*, 1982; USNRC, 1985; 1991; 1994b; 1987; Lutton *et al.*, 1982) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion III-L. *Exclude areas located where the hydrogeology beneath the site discharges groundwater to the land within 3,000 feet of the boundaries of the candidate site*. In addition to the 3,000 foot value being arbitrary (i.e., no methodological basis for determination), hydrogeological conditions and restrictions are adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199, 1200, 1300, and 2700 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987; Lutton *et al.*, 1982) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion III-M. *Exclude areas located above an aquifer that is the primary source of drinking water for a municipality or for persons residing or doing business in the municipality or county where a candidate site is located.* Protection of potable water is adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1165, 1199, 1200, 1300, 2700, and 3164 (Siefken *et al.*, 1982; USNRC, 1985; 1991; 1994b; 1987; Lutton *et al.*, 1982; Lutton, Strohm and Strong, 1983) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion IV-A. *Seek areas which minimize the risk of transportation accidents.* Surveys of existing land use and cultural resources and analyses of impacts of accidents as part of the site selection process are provided for in NUREGs 0696, 0902; 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1980; 1991; 1994b; 1987) and Regulatory Guides 4.19 and 8.29 (USNRC, 1988a; 1996a). In addition, the reduction of risks associated with transportation of LLRW is addressed in 10CFR71.5 and 71.88 (OFR, 1995d) and 49CFR171 - 177 (OFR, 1995e).

Criterion IV-B. *Seek areas which minimize the risk of exposure to radiation associated with transportation accidents.* Surveys of existing land use and cultural resources and analyses of impacts of accidents as part of the site selection process are provided for in NUREGs 0696, 0902; 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1980; 1991; 1994b; 1987) and Regulatory Guides 4.19 and 8.29 (USNRC, 1988a; 1996a). In addition, the reduction of risks associated with transportation of LLRW is addressed in 10CFR71.5 and 71.88 (OFR, 1995d) and 49CFR171 - 177 (OFR, 1995e).

Criterion V-A. *Seek areas with simple meteorological systems that can be characterized, modeled, analyzed, and monitored.* This criterion is adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987), NUREG/CR 3332 (Brenk, Fairobent and

Markee, 1983) and Regulatory Guides 1.23, 4.18, and 4.19 (USNRC, 1986; 1983; 1988a).

Criterion VI-A. *Seek areas where natural resources do not exist on or are significantly near to the candidate site that, if exploited, would result in failure to meet the performance objectives in Subpart C of 10 CFR 61.* This criterion is adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion VII-A. *Exclude areas with wetlands as defined in the Goemaere-Anderson Protection Act, Act No. 203 of the Public Acts of 1979, being sections 281.701 to 281.722 of the Michigan Compiled Laws.* Protection of wetlands is adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion VII-B. *Exclude areas with environmental areas or high risk areas as defined in the Shorelands Protection and Management Act of 1970, Act No. 245 of the Public Acts, being sections 281.631 to 281.644 of the Michigan Compiled Laws.* While not specifically referenced to Michigan's Shorelines Protection and Management Act, impact analysis and protection of sensitive environmental areas is adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion VII-C. *Seek sites which do not cause visual intrusion on designated scenic highways so designated as of January 1, 1988.* This issue is adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion VII-D. *Seek sites which will not require that prime farmland be removed from agricultural production.* While not specifically referenced to prime agricultural production, short and long term impact analyses for agricultural lands are provided for in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion VIII-A.. *Seek areas which are not included in formally proposed or approved development plans as of January 1, 1988.* This issue is adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion IX-A. *Exclude areas where siting will be inconsistent with the requirements of the federal laws:*

(i) Atomic Energy Act of 1954, Chapter 1073, 68 Stat. 919,
(ii) Federal Water Pollution Control Act, Chapter 758, 62 Stat. 1155,
(iii) Coastal Zone Management Act of 1972, Public Law 89-454, 16 U.S.C. 1451 to 1454b, 1455 to 1459, 1461 to 1463, 1464,
(iv) Endangered Species Act of 1973, Public Law 93-205, 87 Stat. 884,
(v) Wild and Scenic Rivers Act. Public Law 90-542, 16 U.S.C. 1271 to 1287,
(vi) Wilderness Act, Public Law 88-5787, 16 U.S.C. 1131 to 1136,
(vii) National Wildlife Refuge System Administration Act of 1966, Public Law 89-669, 16 U.S.C. 668dd, 668ee,
(viii) Chapter 593, 49 Stat. 666, 16 U.S.C. 461 to 467, and
(ix) The National Historic Preservation Act, Public Law 89-665, 16 U.S.C. 470 to 470a, 470b, 470c to 470w-6.

This criterion is adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Criterion IX-B. *Exclude areas where siting will be inconsistent with the requirements of the following state laws:*

(i) State Parks, Public Act 218 of 1919 and Public Act 17 of 1921, and
(ii) Wilderness Areas, Wilderness and Natural Areas Act, Public Act 241 of 1972.

Although Michigan's laws are not specifically referenced, the protection of such lands is adequately addressed in 10CFR61 (OFR, 1995c), NUREGs 0902, 1199, 1200, and 1300 (Siefken *et al.*, 1982; USNRC, 1991; 1994b; 1987) and Regulatory Guides 4.18 and 4.19 (USNRC, 1983; 1988a).

Conclusion

Based on the Panel's review of the Michigan LLRW facility siting criteria mandated under Public Act 204 of 1987 and the provisions contained in 10CFR61 (OFR, 1995c) and its ancillary federal guidance documents, the Panel concludes that all of Michigan's LLRW statutory criteria and all but one non-statutory criteria are either adequately addressed by the federal LLRW isolation facility siting criteria, standards and guidelines

and/or contain arbitrary numerical restrictions without a methodological basis for determination. Consequently, these state statutory and non-statutory criteria are considered to be unwarranted. A single non-statutory state criterion, Criterion VIII-B (which states that if all other criteria are met, then preference should be given to areas near communities desiring the facility), was not found to be unwarranted since no reasonably similar federal provision could be found during the Panel's review.

DIRECTIVE 3: In the judgment of the MESB, can an engineered LLRW isolation facility be located in Michigan without posing dangerous levels of radioactive risk to public health and safety and/or the environment.

An overview of the USNRC regulations and federal guidelines which govern LLRW isolation facilities has been presented previously in this report (see Directive 1). Contained in these regulations and guidelines are provisions which indicate the levels of radiation exposure to the public, workers and intruders which should not be exceeded. In particular, annual radiation dose limits, as a result of release to the general environment, are specified in 10CFR61 (OFR, 1995c) and annual occupational radiation dose limits are addressed for adults, minors and declared pregnant women in 10CFR20 (OFR, 1995a). In addition, specific guidance on these and related issues are also addressed in NUREGs 1199, 1200, and 1388 (USNRC, 1991; 1994b; Shum, Starmer and Young, 1989), Regulatory Guide 8.29 (USNRC, 1996a) and the draft Branch Technical Position on Performance Assessment (USNRC, 1994a).

Ensuring that the levels of radiation from a LLRW isolation facility do not exceed the standards is a function of facility design and construction, limiting (by on-going assessment) the types and amounts of radioactive materials which may be accepted into the facility, proper and consistent management, institutional controls, and, ultimately, properly designed and operating environmental barriers. Based on the Panel's review of the federal regulations, guidelines, and performance standards; presentations from industry and federal agency representatives (Corpstein, 1995; Hornibrook, 1996; Thaggard, 1995); and assuming that the federal siting, design, operation, closure and postclosure standards and all performance standards would be adhered to, the Panel concludes that an engineered, centralized LLRW isolation facility could be sited and operated in Michigan without posing dangerous levels of radioactive risk to public health and safety or the environment.

DIRECTIVE 4: Evaluate the relative risks associated with locating a centralized LLRW isolation facility in Michigan. In conducting this evaluation, consider the discussion on relative risk of LLRW contained in the Michigan Department of Natural Resources' July 1992 report entitled, *Michigan's Environmental and Relative Risk*.

The potential risks which could be associated with locating a LLRW isolation facility may be broadly classified into two general categories, negative health outcomes as a result of environmental radiation exposure and negative health outcomes as a result of occupational radiation exposure. Within each category, the circumstances resulting in such exposure (e.g., coming into contact with radioactive food or water resulting from improperly designed or maintained, or degrading or damaged LLRW isolation facilities and coming into contact with a radiation source on the job) would be highly variable and diverse.

Most data used in the development of risk assessments for radiation exposure have come from studies of high level, short term exposures to humans and animals. Based on these studies, negative health outcomes resulting from high level, acute exposures may be predicted and risk assessment values calculated with some level of certainty. However, at lower levels and durations of exposure, little direct evidence exists and there remains considerable uncertainty as to the actual impact on health. In the absence of this certainty and as a conservative assumption for radiation protection purposes, the scientific community has generally assumed that any exposure to ionizing radiation can cause biological effects that may be harmful to the exposed person and that the magnitude or probability of harm of these effects is directly proportional to the dose (USNRC, 1996; Manno, Riedel and Trembley, 1995).

According to Manno, Riedel and Trembley (1995), estimates of collective radiation dose and risk committed by 50 years of exposure have been derived by Ahier and Tracy (1994) for the Great Lakes basin. The total number of predicted fatalities over the lifetime of the current basin population that could be theoretically attributed to a 50 year exposure to natural background radiation is of the order of 2.4×10^5. By comparison, the total number of predicted fatalities theoretically attributable to radioactive fallout from all weapons tests to date would be of the order of 3,400, and estimates of theoretically attributed fatalities due to exposure to current nuclear fuel cycle effluent (from exposure mainly to H-3 and C-14 releases) are on the order of 140. The predicted fatalities attributed to LLRW for the same time frame was calculated to be less than 0.1.

Michigan's Relative Risk Analysis Project was initiated in September 1991 with the creation of three multi-disciplined committees composed of scientists, citizens and representatives of governmental agencies, respectively. The purpose of each committee was to identify and evaluate known and suspected environmental problems, decide which problems were of particular concern, and assign a relative rank to each by comparing the risks each posed to the environment and quality of life. The resulting report, entitled,

Michigan's Environment and Relative Risk, (Rustem *et al.*, 1992) was presented to the Governor in July 1992.

The relative risk report identified 24 environmental risk issues and ranked each in terms of concern as either "High-High", "High", "Medium-High", and "Medium". The issue, “Generation and Disposal of Low-Level Radioactive Waste” was assigned a relative risk ranking of “Medium-High”. The report states that, “*…Under completely uncontrolled conditions, …*[LLRW] *wastes have the potential for producing adverse effects in humans and the environment, and therefore, they need to be properly managed in order to limit potential risk.*” As has been discussed previously (see Directives 1 and 3), considerable control is exerted by the federal LLRW facility siting and operating regulations and guidelines over the environmental and occupational sources and avenues of potential radiation exposure in order to minimize as much as possible both the dose and length of exposure. Based on the Panel’s previous evaluations of the environmental and human protective measures afforded by the federal LLRW regulations and guidelines, and assuming that the federal regulations and guidelines are closely adhered to and monitored, the Panel concludes that risks of locating and operating an engineered, centralized LLRW isolation facility would be minimal.

DIRECTIVE 5: Consider the relative risk of developing an engineered, centralized waste isolation facility with the risk of doing nothing; i.e., continuing to store LLRW at the approximately 50 existing locations.

During the time frame when the MDNR environmental and relative risk report (Rustem *et al.*, 1992) was developed, Michigan's LLRW generators were unable to ship their annually generated waste to outstate LLRW isolation facilities (Public Sector Consultants, 1995; MDC, 1995; 1993). Consequently, the state's LLRW generators were forced to store their accumulating wastes on-site in temporary facilities that were neither designed nor regulated as permanent repositories. It was for this reason, in part, and also the absence of any imminent relief from this circumstance that the relative risk issue "Generation and Disposal of Low-Level Radioactive Waste" was placed in the category of "medium-high" risk in the MDNR (Rustem *et al.,* 1992) report. The report states that "... *Once the issue of final storage is resolved,* [the] *risks will be reduced ... .*" With the relatively recent opening of the Barnwell, South Carolina LLRW facility to Michigan LLRW generators, the concern about temporary storage of the previously accumulated and currently accumulating annual operational LLRW has lessened. However, the length of time that the Barnwell facility will continue to take Michigan generated waste is unknown.

In addition to the normal operational LLRW waste, it is currently anticipated (Strong, 1996) that five of the nuclear power reactors in Michigan will complete their useful life by the year 2025 and be decommissioned. This will result in even more Class A, B, and C LLRW (Public Sector Consultants, 1995) for which a permanent disposal alternative will be needed. If no centralized LLRW isolation facility is available in Michigan, this waste, along with the annual operational LLRW, will need to be either stored on-site at the place where it is produced, or transported out of Michigan to another facility. Michigan has already experienced being denied outstate LLRW disposal during 1990 - 1995. In the absence of a guaranteed outstate or in state disposal facility, the potential for accidental radiation exposure to the public, workers and possible intruders which would be associated with temporary LLRW storage facilities would (again) exist and increase.

Public Sector Consultants (1995) has thoroughly looked at the advantages and disadvantages of developing a centralized waste isolation facility versus continuing the practice of storing LLRW temporarily at the individual generator sites. The construction of an engineered, centralized LLRW isolation facility will provide a lower risk to Michigan's citizens than the previous (and potentially future) practice of LLRW generator on-site temporary storage for several reasons. First and foremost, Michigan LLRW generators do not have the facilities or space to store any significant volume of LLRW for an extended period of time (MDC, 1995) and the expectation of secure long term (on the order of 500 years) storage of LLRW at the numerous generator sites is neither practical nor realistic when compared to disposal at a single site specifically designed and regulated to securely isolate LLRW (Public Sector Consultants, 1995). Second, the USNRC currently can only minimally regulate generator storage of LLRW

through USNRC Informational Notices (USNRC, 1990; 1989a) rather than through promulgated, and therefore, more readily enforceable regulations. Third, the LLRW waste streams from Michigan generators are highly diverse and variable in volume and radioactivity (see Tables 1 and 2, and Appendix 2) and would represent a wide variety of employed local storage options, waste reduction techniques and practices, and management decisions which would be difficult to uniformly monitor and control. Fourth, the management and maintenance of long term secure LLRW storage facilities at the generator sites would require a greater number and different and more diverse level of staff expertise than currently exists at the generator sites. And fifth, enlarging the role of the LLRW generators to also provide indefinite, temporary storage of LLRW represents only a interim rather than a permanent solution to the disposal of LLRW.

The conclusion reached by Public Sector Consultants (1995) was that "*... A permanent waste isolation facility can provide for LLRW management more economically and efficiently than* [can] *separate temporary storage facilities, whether on-site storage or centralized ... .*" The Panel concurs with this conclusion. Given the significant amounts of annual operational LLRW that already exist, and continue to be produced, and the currently anticipated additional decommissioning waste, the construction of an engineered, centralized LLRW facility would clearly provide important measures of security missing at present and an economy of scale by combining the supervision and monitoring of the present decentralized and diverse temporary storage facilities.

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APPENDIX 1

July 26, 1995 Letter from Governor John Engler to the Michigan Environmental Science Board

July 26, 1995

Dr. Lawrence Fischer, Chair
Michigan Environmental Science Board
Lewis Cass Building, 2nd Floor
P.O. Box 30026
Lansing, Michigan 48909

Dear Dr. Fischer:

Under federal law, the State of Michigan is responsible for providing final disposal capacity for the low-level radioactive waste (LLRW) generated within the state. Public Act 204 of 1987 established the Michigan Low-Level Radioactive Waste Authority (Authority), a set of minimum siting criteria, a process for selecting a site, financing, and developing a waste-isolation facility.

Michigan began its site-selection process in 1989, with the completion of a statewide exclusionary screening and identification of three candidate areas. Following the eventual elimination of these three areas under state siting criteria, it became evident that the siting criteria embodied in PA 204 may be so restrictive as to prohibit siting a facility within the state. Subsequent studies have supported this conclusion. As a result of Michigan's inability to site a waste-isolation facility, access to the nation's only two operating disposal facilities was cut off in November 1990 ad LLRW has been stored at about 50 locations around the state.

The Authority, with the help of an independent Board of Governors is currently in the process of developing a volunteer host-community process deemed to be more likely to succeed in identifying a site than the existing state-run siting process. Even a volunteer process, however, cannot succeed if the siting criteria would rule out consideration of every volunteered site.

I am writing to request that the Michigan Environmental Science Board (MESB) evaluate the scientific basis for Michigan statutory siting criteria and federal siting standards. This evaluation should determine the following:

1.Whether Michigan's environment and/or geology pose unusual or unique conditions that would not be fully recognized, evaluated, and protected under federal siting regulations contained in 10 CFR 61 and the Nuclear Regulatory Commission's standards for performance-assessment studies.

2.Given your assessment of the protections afforded by federal siting and performance standards, and your review of any unique environmental conditions found in Michigan, are any of Michigan's statutory siting criteria unwarranted?

3.In the judgement of the MESB, can an engineered LLRW isolation facility be located in Michigan without posing dangerous levels of radioactive risk to public health, safety, or the environment?

In addition to the above evaluation, I am requesting that the MESB evaluate the relative risk associated with locating a centralized LLRW isolation facility in Michigan. Specifically, I ask your assistance in comparing the relative risk of living close to a LLRW isolation facility with other common radiation risks, e.g., x-rays and other medical treatments, exposure to radon gas, sunbathing, flying in an airplane, etc.

In conducting this evaluation, please consider the relative risk of developing an engineered, centralized waste-isolation facility with the risk of doing nothing, i.e., continuing to store the LLRW at the approximately 50 existing locations.

To assist you in these endeavors, I am directing the Departments of Natural Resources and Public Health, as well as the Authority, to fully cooperate with and support the MESB's investigation. I would also encourage the MESB to also seek assistance in this assignment from appropriate federal agencies, other state and interstate compacts, environmental organizations, and your peers in the academic and scientific communities.

The Board of Governors will report on LLRW management options and make recommendations to the Legislature in early September for the development of a volunteer host-community siting process. Since Michigan law will have to be changed to accomodate this new process, your evaluation of the siting criteria is important, and I would appreciate receiving it by the end of October.

Thank you for your continuing service to the state of Michigan.

Sincerely,

John Engler
Governor

APPENDIX 2

Shipped Low-Level Radioactive Waste from Michigan Universities, Governmental Facilities, Industries, Hospitals and Power Plants in 1990 and 1995.

Tables 1-5 present data on low-level radioactive wastes which were shipped in 1990 and 1995 from Michigan generators to the low-level radioactive waste isolation facility at Barnwell, South Carolina.

Table 1. Shipped Low-Level Radioactive Waste from Michigan Universities in 1995 and 1990.[(a)]

Isotope	1995 Activity (millicuries)	1995 Volume (cu. ft.)	1990 Activity (millicuries)	1990 Volume (cu. ft.)
cadmium - 109	----	----	0.02	----
calcium - 45	----	----	8.71	----
carbon - 14	0.54	----	37.15	----
cerium - 141	----	----	2.18	----
cesium - 134	----	----	0.32	----
chromium - 51	----	----	13.96	----
cobalt - 56	----	----	0.86	----
cobalt - 57	----	----	9.20	----
cobalt - 58	----	----	2.61	----
cobalt - 60	----	----	5.30	----
europium - 152	----	----	1.55	----
germanium - 68	----	----	3.93	----
hydrogen - 3	0.81	----	241.31	----
indium - 111	----	----	0.02	----
iodine - 125	----	----	301.74	----
iodine - 131	----	----	0.54	----
iron - 59	----	----	0.67	----
manganese - 54	----	----	3.42	----
niobium - 95	----	----	0.02	----
phosphorus - 32	----	----	15.30	----
rubidium - 86	----	----	0.40	----
ruthenium - 103	----	----	2.08	----
scandium - 46	----	----	5.98	----
silver - 110M	----	----	23.69	----
sodium - 22	----	----	0.95	----
strontium - 89	----	----	0.01	----
sulfur - 35	----	----	130.69	----
tin - 113	----	----	5.47	----
zinc - 65	----	----	19.54	----
Total	1.35	12.00	837.62	445.60

(a) Modified from Chem-Nuclear Systems, 1996a; 1996b.

Table 2. Shipped Low-Level Radioactive Waste from Governmental Facilities in Michigan in 1995 and 1990.

Isotope	1995 Activity (millicuries)	1995 Volume (cu. ft.)	1990 Activity (millicuries)	1990 Volume (cu. ft.)
carbon - 14	0.39	----	----	----
cesium - 137	0.08	----	0.01	----
hydrogen - 3	210,001.64	----	9,785.00	----
Total	210,002.11	6.50	9,785.01	1.00

Table 3. Shipped Low-Level Radioactive Waste from Michigan Industries in 1995 and 1990.[(a)]

Isotope	1995	1995	1990	1990

	Activity (millicuries)	Volume (cu. ft.)	Activity (millicuries)	Volume (cu. ft.)
barium - 133	0.13	----	----	----
calcium - 45	3.01	----	0.18	----
carbon - 14	1260.14	----	4.31	----
cesium - 137	184.40	----	----	----
chlorine - 36	14.00	----	----	----
chromium - 51	----	----	0.02	----
cobalt - 60	0.18	----	----	----
hydrogen - 3	7,365.58	----	12.17	----
iodine - 125	1.62	----	9.44	----
iron - 55	2.36	----	----	----
krypton - 85	2.52	----	----	----
nickel - 63	127.49	----	0.20	----
phosphorus - 32	0.12	----	0.79	----
phosphorus - 33	0.29	----	----	----
promethium - 147	2.60	----	----	----
silver - 110M	0.03	----	----	----
sodium - 22	0.03	----	----	----
strontium - 90	5.47	----	----	----
sulfur - 35	----	----	0.07	----
thorium - 232	1.00	----	----	----
uranium - 235	0.01	----	----	----
uranium - 238	3.64	----	----	----
Total	8974.62	592.90	27.18	33.30

Table 4. Shipped Low-Level Radioactive Waste from Michigan Hospitals in 1995 and 1990.[(a)]

Isotope	1995 Activity (millicuries)	1995 Volume (cu. ft.)	1990 Activity (millicuries)	1990 Volume (cu. ft.)
barium - 133	0.09	----	----	----
calcium - 45	0.06	----	1.89	----
carbon - 14	20.90	----	2.19	----
cesium - 137	0.21	----	----	----
cobalt - 57	2.30	----	0.16	----
gadolinium - 153	0.01	----	----	----
hydrogen - 3	225.99	----	21.35	----
iodine - 125	----	----	54.34	----
phosphorus - 32	----	----	32.06	----
radium - 226	0.02	----	----	----
sodium - 22	0.01	----	----	----
sulfur - 35	6.54	----	5.95	----
uranium - 238	0.20	----	----	----
Total	256.33	82.87	117.94	120.30

(a) Modified from Chem-Nuclear Systems, 1996a; 1996b.

Table 5. Shipped Low-Level Radioactive Waste from Michigan Power Plants in 1995 and 1990.[a]

Isotope	1995 Activity (millicuries)	1995 Volume (cu. ft.)	1990 Activity (millicuries)	1990 Volume (cu. ft.)
americium - 241	3.81	----	8.30	----
antimony - 122	1.92	----	7.41	----
antimony - 124	2.73	----	495,057.58	----
antimony - 125	3,294.73	----	55,221.14	----
barium - 131	-----	----	118.00	----
barium - 133	201.81	----	-----	----
barium - 140	0.16	----	-----	----
carbon - 14	23,684.45	----	7,318.39	----
cerium - 141	15.79	----	0.17	----
cerium - 144	1,073.65	----	152.23	----
cesium - 134	29,613.51	----	22,649.26	----
cesium - 136	-----	----	0.12	----
cesium - 137	105,593.80	----	87,674.50	----
chromium - 51	5,327.67	----	127,897.49	----
cobalt - 57	110.72	----	90.88	----
cobalt - 58	3,655.61	----	54,702.16	----
cobalt - 60	444,556.42	----	6,288,594.39	----
curium - 242	8.75	----	7.15	----
curium - 244	3.61	----	12.26	----
hafnium - 181	37.65	----	-----	----
hydrogen - 3	6,275.57	----	51,905.81	----
iodine - 129	42.76	----	45.46	----
iodine - 131	0.15	----	356.28	----
iron - 55	406,161.62	----	12,316,924.58	----
iron - 59	107.57	----	3,869.07	----
manganese - 54	48,240.38	----	1,293,459.38	----
nickel - 59	147.47	----	1,567.00	----
nickel - 63	116,171.31	----	278,752.41	----
niobium - 94	-----	----	5.01	----
niobium -95	78.46	----	95.66	----
niobium - 97	0.08	----	-----	----
plutonium - 238	3.31	----	8.66	----
plutonium - 239	6.97	----	9.61	----
plutonium - 241	232.33	----	517.91	----
ruthenium - 103	9.34	----	-----	----
ruthenium - 106	154.30	----	-----	----
silver - 110M	120.60	----	4,696.55	----
sodium - 22	23.03	----	-----	----
strontium - 89	0.07	----	15.57	----
strontium - 90	368.60	----	1,194.12	----
technetium - 99	810.08	----	210.30	----
tellurium - 125M	392.19	----	125.72	----
tin - 113	-----	----	0.54	----
xenon - 131M	-----	----	1.01	----
zinc - 65	21,909.80	----	143,355.92	----
zirconium - 95	34.56	----	4,502.54	----
Total	1,218,477.34	19,836.00	21,241,132.56	26,896.70

(a) Modified from Chem-Nuclear Systems, 1996a; 1996b.

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APPENDIX 3

Comparison of U.S. Nuclear Regulatory Commission, Michigan, and Selected States Low-Level Radioactive Waste Isolation Facility Siting Criteria Regulations

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The following tables provide a comparative matrix of low-level radioactive waste (LLRW) isolation facility siting criteria regulations for the U.S. Nuclear Regulatory Commission (USNRC), Michigan and twelve selected states (OFR, 1995c; CHWMS, 1995; ILLRWTG, 1995; LLRWMB, 1995; NCDEHNR, 1993; MDC, 1991; 1989; NC, 1975). The regulations have been divided into the following eight general siting criteria subject areas:

1. Population,
2. Geological and flood hazards,
3. Hydrogeological factors,
4. Transportation,
5. Meteorology,
6. Environmental and resource factors,
7. Economic and social factors, and
8. Site Size and Special Limits.

Each subject area is divided into from 1 to 11 sub-areas based on similar topics of discussion in the regulations. The sub-areas are numbered left of the tables to facilitate use of the tables. Where the USNRC has a regulation for a particular subject and sub-area, that regulation is listed in the leftmost column. Each table, except for the one on meteorology, is on three pages, with the USNRC and the states listed across the top. The large number of state regulations in some areas (e.g., geological and flood hazards, hydrogeological factors, environmental and resource factors, and economic and social factors) necessitated more than one table per subject.

The LLRW regulatory comparative matrix is based on a similar matrix prepared by the Michigan LLRW Authority in 1991 (MDC, 1991), which provided a comparison of state LLRW regulations for Michigan, Texas, New York, Nebraska, Massachusetts, Pennsylvania, California, Vermont, Connecticut, North Carolina, New Jersey, Illinois, and Maine. Each state was subsequently contacted by the Michigan Environmental Science Board (MESB) in the fall of 1995 to determine whether there had been changes in the state's LLRW regulations. Four states, Massachusetts, Connecticut, North Carolina, and Illinois indicated that they had made changes. Except for Illinois, each state sent copies of its new regulations to the MESB. Illinois is currently working on revised regulations; however, they were not completed in time for inclusion into this matrix. Both Connecticut and Massachusetts have established volunteer siting programs. The changes are noted in the tables. Deleted regulations are underlined and in brackets; where a new or substitute regulation has been added, the text is bolded. Normal text represents unchanged regulations.

Population

All the states except California repeat the USNRC criteria that a site should be located where future growth and development will not affect the site's ability to meet performance objectives and where the ability to monitor the site will not be compromised. Three states, New York, Connecticut and Maine, require that low population density be considered in siting. Michigan and New York are more restrictive than other states and the USNRC, prohibiting siting within incorporated city limits. New York state goes on to exclude villages and towns and any area having population density of over 1,000 persons per square mile in 1980.

Geological and Flood Hazards

All the states except Michigan and California restate the USNRC requirement to avoid areas where tectonic processes are such that they preclude adequate modeling. Massachusetts and Connecticut initially had very specific requirements (e.g., ten miles from and geologic fault, 200 feet from a bedrock fault active during the Holocene Epoch) which have been modified since in favor of the general USNRC requirements. California requires that areas be excluded if they are within an earthquake fault setback 1/2 mile perpendicular and two miles from the end of a fault. Michigan's rules are the most restrictive in this

area, requiring exclusion of sites located one mile or less from a fault where tectonic movement has occurred in the past 10,000 years or areas with a modified Mercali Index of VII or greater.

Areas within the 100 year flood plain are excluded in each state, as in USNRC regulations. Michigan, Vermont and Maine exclude areas in the 500 year flood plain, exceeding USNRC regulations. Massachusetts and Connecticut have changed their original 500 year flood plain exclusions to 100 year flood plain exclusions since 1990. Four states, Massachusetts, Pennsylvania, Vermont and New York, prohibit siting where failure of a dam could compromise performance. Seven of the states have regulations about avoiding areas where upstream drainage and excessive runoff could cause inundation or erosion at a site.

Most states, including Michigan, have a regulation which duplicates the USNRC's, excluding areas of certain geological processes, such as mass wasting, slumping, landsliding, etc. Four states, Massachusetts, Pennsylvania, Connecticut, and Maine, exclude areas where slopes are greater than 20%, 15%, 15% and 20%, respectively.

Hydrogeological Factors

All states, including Michigan, have hydrogeological regulations similar to the USNRC's and all call for prohibiting groundwater intrusion into the waste. New York makes an exception if it can be shown conclusively that molecular diffusion will be the predominant means of radionuclide movement, but still does not allow the LLRW isolation unit within the zone of fluctuation of the water table. Massachusetts has eliminated specific requirements about the distance between the waste management area and the water table (10 feet minimum, 30 feet over the entire area). California law indicates that areas with less than 100 feet to groundwater should be avoided; North Carolina mandates seven feet to the highest water table, Maine two feet, and Connecticut five feet to the seasonal high water table. Six states, including Michigan, prohibit the location of sites over sole source aquifers or aquifer recharge zones. Six states also have specific regulations dealing with underlying soil conditions that will retard the movement of water. Connecticut regulations require that all its water laws must be taken into consideration in the siting process.

Maine has 14 regulations regarding hydrogeology that are in addition to the USNRC regulations; Michigan and Massachusetts each have ten additional regulations. Additional regulations for the ten remaining states range from one to seven. These states exceed the USNRC regulations.

Transportation

Eleven of the 13 states have regulations regarding transportation in the siting process. Nebraska has none, and Connecticut has eliminated its four, rather comprehensive, regulations since 1990. Connecticut’s current regulations emphasize minimizing the risk of exposure resulting from traffic accidents, keeping waste away from populated areas, and locating centrally to minimize road miles. Texas encourages rail or barge transportation. Michigan's two regulations are general, having to do with minimizing the risk of accidents and exposures associated with such accidents.

Meteorology

While the USNRC does not specifically limit siting as a result of a specific meteorological factor, it does require a thorough evaluation of the metrology and technical analysis of various pathways, including air, in order to demonstrate protection of the general populations from release of radioactivity. Six of the 13 states have a regulation regarding specific meteorological conditions. New Jersey specifically mandates that the site selection process consider the potential for biotic and airborne mechanisms for the transport of radionuclides, in addition to looking at surface water and groundwater transport. Michigan requires that the site selected possess simple meteorological systems in order that it can be can adequately modeled, analyzed and monitored.

Environmental and Resource Factors

USNRC regulations prohibit siting facilities in areas containing wetlands, as do all the states except Nebraska, Connecticut and North Carolina. Massachusetts requires that the site not be within one-half mile of an existing important wetland, Vermont 100 meters from any wetland, and Massachusetts 100 feet from any wetland. All states except North Carolina, Pennsylvania and Nebraska prohibit development in coastal high hazard zones, as does the USNRC. A third USNRC regulation concerning environmental and resource factors states that areas are to be avoided having known natural resources which, if exploited, could affect the site adversely. Massachusetts, Connecticut and North Carolina had a similar regulation in 1990, but have since eliminated it. The remainder of the 13 states have regulations similar to those of the USNRC. Michigan, California and Maine have additional laws protecting scenic areas from visual intrusion. Eight of the states, including Michigan, have laws protecting agricultural land. Michigan is, again, more restrictive that the USNRC, having requirements that restate the three basic USNRC criteria in this area, and adding criteria about visual intrusion and removal of prime farmland.

Michigan regulations contain a provision to, "*Exclude areas where siting will be inconsistent with federal and state laws protecting environmentally sensitive areas, cultural and heritage values, and areas dedicated as national and state parks and wilderness preservation areas*." This is consistent among the other states, except Nebraska, which has no like requirement, although other states have added specific protection for areas of archeological significance, historic sites, Indian reservations, critical habitat areas, and recreational areas. Massachusetts and Connecticut have dropped lengthy and detailed exclusions in favor of more general statements, since other USNRC regulations address adherence to state and federal environmental and resource laws.

Economic and Social Factors

Michigan exceeds USNRC criteria in this area. Michigan, California and Maine exclude areas in existing development plans. Michigan gives preference to communities that want the facility. A few states have regulations indicating that the state must be able to obtain title of the land, and some have regulations regarding minimizing costs and about locating near existing labor pools. There are also regulations prohibiting siting in particular areas. Texas excludes areas within 20 miles of Army Corps of Engineer projects and New York excludes the Western New York Nuclear Service Center. Massachusetts has eliminated its very detailed regulation regarding airport runways, mines, above ground storage tanks, etc. Massachusetts, Connecticut and Maine are the only states with regulations regarding sensitive populations. Massachusetts requires that proximity to sensitive populations be considered, especially under conditions of accidental release; Maine requires that sites be amenable to establishing a baseline for monitoring health effects in the local population. In its volunteer program, Connecticut requires that any facility apply for and receive a Certificate of Public Safety and Necessity demonstrating that the health and safety of the surrounding population will not be jeopardized by the siting.

Site Size and Special Limits

Michigan exceeds the USNRC regulations in terms of site size, requiring a buffer zone of at least 3,000 feet between the LLRW isolation unit and adjacent property lines, and applying Michigan's internal dimensioning criteria would require a site to be no less than 6,200 feet (1.15 miles) in diameter. Massachusetts' old criteria required the site to have a 500 foot buffer zone, which is equivalent to a 22 acre disc or a 28 acre square as a minimum. Other criteria limit site elevation and upgrade site drainage. Michigan and Connecticut require a site large enough for specified buffer zones (3,000 feet and 300 feet, respectively), while New York, Massachusetts and Vermont require buffer zones but do not specify the size. Massachusetts had required a 500 foot buffer between the waste management area and abutting parcels of land, but has since eliminated that requirement.

Siting Criteria 1. Population (page A).

	NRC	Michigan	Texas	New York	Nebraska
1		Exclude areas within incorporated city limits as established on 1/1/88		Exclude areas located within any village, town, city or incorporated area having an average population density of more than 1,000 individuals per square mile as determined from the 1980 or more recent census	
2	A disposal site should be selected so that projected population growth and future development are not likely to affect the ability of the disposal facility to meet the performance objectives of 10CFR61 Subpart C. The disposal site must not be located where nearby facilities or activities could adversely impact the ability of the disposal site to meet performance objectives of 10CFR61 Subpart C or significantly mask the environmental monitoring program	Seek areas where projected population growth and future developments are not likely to affect the ability of the disposal facility to meet performance objectives in 10CRF61 Subpart C and are not likely to significantly interfere with an environmental monitoring program	Disposal facility shall not be located where nearby facilities or activities could adversely impact the site's ability to meet performance objectives	Seek areas where present and projected effects from population growth and other developments will not adversely affect the facility's ability to meet the performance objectives contained in 10CFR61 Subpart C or mask the environmental monitoring program Exclude areas where currently existing radioactive material, including but not limited to naturally occurring radioactive material may mask the monitoring program	Seek areas where projected population growth and future developments are not likely to affect the ability of the facility to meet performance objectives. Areas shall be avoided where nearby facilities or activities could preclude the site from meeting performance objectives or could mask the environmental monitoring program. Dimensions to carry out environmental monitoring and take mitigating measures if needed
3			The area to be used as the disposal unit should have no recorded easements on it		
4				The site must be located based on a consideration of population density in the vicinity of the site to keep the potential population dose as low as reasonably achievable	
5					
6					
7					

Regulations no longer in effect (changed since 1990) are underlined and in brackets.
Regulations added since 1990 are in bold type.

Siting Criteria 1. Population Continued (page B).

	Massachusetts	Pennsylvania	California	Vermont	Connecticut
1	[Exclude urbanized areas as defined by the US Census Bureau as of the date of the initiation of the site selection process (Category A)] **Exclude sites where the existing population density, projected population growth, or future development in the vicinity of the site is reasonably likely to interfere with the ability of the facility to meet DPH objectives**		Exclude areas within the boundary of projected population growth	To be established by rule: Population density of surrounding area and impacts on local governmental units	[Avoid land that is classified as an *urban growth area*, an *urban center*, and *urban conservation area* or a *rural community center] [*Prefer land that is further away from land classified as an *urban growth area*, an *urban center*, an *urban conservation area*, or a *rural community center]* [Prefer land that has a lower population density and is further away from residential areas] **Consider current and projected population density in the area where the facility is to be located**
2		Exclude sites located where nearby facilities, activities, population or development will mask monitoring of the disposal site or affect the site's compliance with performance objectives.		Exclude areas where projected population growth and future developments, nearby facilities or activities or any existing radioactive materials could preclude the facility from meeting performance standards	Avoid land where nearby facilities or activities could adversely impact ability to meet performance objectives or could significantly mask the environmental monitoring program. Avoid land where projected population growth and future development are likely to affect ability to meet performance objectives. Prefer land that is further away from facilities or activities that could preclude the site from meeting performance objectives
3					
4					
5			Avoid individual residences or occupied structures		
6			Avoid established seasonally occupied struc-tures or sites		
7			Seek availability of emergency response, and health care services		

Siting Criteria 1. Population Continued (page C).

	North Carolina	New Jersey	Illinois	Maine
1		The disposal site shall be selected to limit disruption of existing land use and so that the present population and land use in the area are not likely to affect ability of the disposal facility to meet performance objectives The disposal site selection process shall attempt to avoid areas where facilities or activities could adversely impact on the ability of a site to meet performance objectives or significantly mask the environmental monitoring program		Prefer sites with minimum population density in the surrounding area Exclude areas with facilities or activities that could adversely affect site performance or monitoring Prefer sites with minimum exposure to manmade hazards
2	[The site region should not be target for future development of residences, business, and manufacturing] [The site should not be next to activities that might affect its performance and prevent accurate monitoring of the disposal site for radioactivity]	Seek areas where projected population growth and future developments are not likely to affect the ability of the disposal facility to meet performance objectives contained in 10CFR61 Subpart C and are not likely to significantly interfere with an environmental monitoring program	Within the region where the facility is to be located, a disposal site shall be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet performance objectives The disposal site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet performance objectives or significantly mask the environmental monitoring program	
3				
4				
5				
6				
7				

Siting Criteria 2. Geological and Flood Hazards (page A).

	NRC	Michigan	Texas	New York	Nebraska
1					
2					
3	Avoid areas where tectonic processes such as faulting, folding, seismic activity, or volcanism may occur with such frequency and extent to significantly affect the ability of the disposal facility to meet the performance objectives of 10CFR61 or may preclude defensible modeling and prediction of long-term impacts	Exclude areas located 1 mile or less from a fault where tectonic movement has occurred within the last 10,000 years.	Areas must be avoided where tectonic processes such as faulting, folding, seismic activity, or volcanism occur with such frequency and extent to significantly affect site performance	Exclude areas where tectonic processes such as faulting, folding, seismic activity or volcanism may occur with such frequency and extent as to effect the ability of the disposal site to meet the performance objectives of 10CFR61 or may preclude defensible modeling and prediction of long-term impacts	Avoid areas where tectonic processes, such as faulting, folding, seismic activity, or volcanism may occur with such frequency and extent to significantly affect the ability of the disposal site to meet performance objectives or may preclude defensible modeling and prediction of long-term impacts
4		Exclude areas of significant earthquake intensity, defined as zones with a modified Mercali Index of VII or greater			
5	Waste disposal shall not take place in the 100-year flood plain	Exclude areas within the 500-year flood plain	Disposal sites shall not be located in the 100-year flood plain	Exclude areas within the 100-year flood plain Exclude areas designated as flood hazard areas by FEMA	Exclude areas within the 100-year flood plain
6				Exclude areas located downstream of a dam or other natural structure where failure of such a structure could preclude the facility from meeting performance objectives	
7					
8				Avoid areas where surface run-off could expose, erode or inundate the disposal unit	

Siting Criteria 2. Geological and Flood Hazards Continued (page B).

	Massachusetts	Pennsylvania	California	Vermont	Connecticut
1	The site exhibits relatively simple geology and low relief (Category B)				
2	Exclude locations containing any abandoned under-ground mines or surface quarries or excavations that have extended more than 30 feet below the top of the water table (Category A)				
3	[There shall be no capable geologic fault within one mile of the site (Category A)]. [There shall be no ca-pable geologic fault within 10 miles of the site **Exclude sites where tectonic processes in the vicinity, such as faulting, folding, seismic activity, or volcanism are reasonably likely to adversely affect the ability of the probable waste management area to meet DPH performance objectives or preclude adequate modeling and prediction of long term impacts**	Exclude areas located within 1 mile of an active fault. A disposal site shall be tectonically stable so as to meet performance objectives. Avoid areas where tectonic processes such as faulting, folding, or seismic activity may occur with a frequency and to an extent which may affect the isolation of waste and the long term stability of the site	Exclude areas within earthquake fault setback (1/2 mi. perpendicular, 2 mi. from end of fault) Exclude volcanism centers	Exclude sites located where tectonic processes such as faulting, folding, seismic activity, or volcanism may occur with such frequency and extent to significantly affect ability to meet performance objectives	[Exclude land located less than 200 feet from a bedrock fault that has been active during the Holocene Epoch Exclude land where tectonic processes may occur with such frequency and extent to preclude the facility from meeting performance objectives or may preclude defensible modeling Prefer land that minimizes the potential for adverse impacts on the disposal facility from local or regional tectonic activity]. **Regulations prohibit disposal where significant tectonic processes such as faulting, folding, seismic activity, or volcanism are likely to occur**
4	Soils underlying the waste management area shall have minimal potential for liquefaction or cyclic mobility under maximum seismic loading conditions (Category A)				
5	The waste management area shall be outside any 100-year flood plain (Category A). [The waste management area shall be outside any 500-year flood plain (Category B)]	Exclude sites located within the 100 year flood plain as defined in the Flood Plain Management Act. Exclude sites located within a coastal flood plain as defined in the federal flood plain management guidelines	Exclude areas within the 100-year flood plain, sites located in arroyos or dry washes, and sites located within the upstream or downstream influence of man-made dams or floodways	Exclude areas located within a 500-year flood plain	Exclude land that is inside the boundary of a 100-year flood plain [Prefer land that is not in the 500-year flood plain]
7	The waste management area shall be outside any area subject to inundation by the failure of an existing dam (Category A)	Exclude areas located below a dam which may be threatened with loss of life or serious damage to property if a failure of the dam occurs		Exclude sites located in areas where failure of a dam or impoundment could adversely affect ability to meet performance objectives	
7			Avoid areas designated for emergency release of waters		
8		A disposal site shall be lo-cated so that upstream drainage areas are minimi-zed to decrease the amount of runoff which could erode or inundate waste disposal units	Exclude areas where upstream drainage would create problems such as sites located down-gradient from mountain canyons where flash flooding is likely to occur	Exclude areas located where excessive upstream drainage could erode, expose, or inundate waste disposal units	

Siting Criteria 2. Geological and Flood Hazards Continued (page C).

	North Carolina	New Jersey	Illinois	Maine
1				
2				
3	[The site should not be placed where the earth is likely to be disturbed by natural events such as volcanic action or earthquakes]	The disposal site selection process shall avoid areas where tectonic processes such as faulting, earthquakes, folding or volcanism may occur with such frequency and extent to significantly affect ability to meet performance objectives or preclude defensible modeling and prediction of long-term impacts	Areas shall be avoided where tectonic processes such as faulting, folding, seismic activity, or volcanism occur to such an extent that they could affect the ability of the disposal site to meet performance objectives or would preclude defensible modeling and prediction of long term impacts	Prefer sites having minimum potential exposure to geologic hazards
4				
5	Waste disposal shall not take place in the 100-year flood plain	Disposal units shall not be located in the 100-year flood plain	The facility shall be located outside the boundary of the 100-year flood plain as determined by DOT	Exclude areas within the 500-year flood plain
6				
7				
8	Upstream drainage areas shall be minimized to decrease the amount of runoff which could erode or inundate disposal units There should be no large possible sources of runoff water above the site	The disposal site shall be located so that upstream drainage areas contributing to flow across the site are minimized	Upstream drainage areas shall be minimized to decrease the amount of runoff which could erode or inundate waste disposal units	

Siting Criteria 2a. Geological and Flood Hazards (page A).

	NRC	Michigan	Texas	New York	Nebraska
1	Areas must be avoided where surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of 10CFR61 Subpart C or may preclude defensible modeling and prediction of long-term impacts	Exclude areas where geological processes such as mass wasting, erosion, slumping, landsliding or weathering preclude meeting performance objectives or preclude defensible modeling and prediction of the long term impact of such occurrence	Avoid areas where surface geological processes, such as mass wasting, erosion, slumping, landsliding and weathering occur with such frequency as to adversely affect site performance	Exclude areas where surface or subsurface geologic conditions or processes such as mass wasting, subsidence, erosion, solutioning, slumping, landsliding or weathering preclude meeting performance objectives, or preclude defensible modeling and prediction of long-term impacts	Exclude areas where surface geologic processes such as mass wasting, erosion, slumping, landsliding or weathering occur with such frequency and extent to preclude meeting performance objectives or to preclude defensible modeling and prediction of long term impacts
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Siting Criteria 2a. Geological and Flood Hazards Continued (page B).

	Massachusetts	Pennsylvania	California	Vermont	Connecticut
1	[The continuation of surfical geologic processes at the same rates at which they have occurred during the previous 1,000 years of sporadic surface geologic events that have been experienced during the last 1,000 years shall not be such that they would be expected over the next 500 years to modify the site in any way that would cause it to fail to meet any Category A conditions (Category A)] [Reasonably foreseeable surfical geologic process that are expected to occur at the site or that could occur elsewhere but affect the site shall not be such that they are expected over the next 500 years to modify the site in any way that would cause it to fail to meet any of the Category A conditions] **Exclude sites where the probable waste management area would be located in the vicinity of surface geologic processes such as mass wasting, erosion, slumping, land-sliding, which occur with such fre-quency and extent that such events would be reasonably likely to adver-sely affect the ability of the site to meet any DPH performance objec-tives or preclude adequate modeling and prediction of long term impacts**	Exclude areas located where erosional processes, or mass movement of landforms, such as mass wasting and landslides would affect the long term stability and isolation of waste. Seek areas where topography and surface processes occur at rates, frequency, and extent that will not affect meeting performance objectives	Exclude landslide areas, sand dunes and unstable soil areas	Exclude sites where geologic processes such as mass wasting, erosion, slumping, landsliding or weathering occur with such frequency and extent as to significantly affect ability to meet performance objectives	[Exclude land where surface geologic processes occur with such frequency and extent as to significantly affect the ability of the site to meet NRC performance objectives or may preclude defensible modeling and prediction of long term impacts] [Avoid land where surface geological processes may occur with such frequency and extent to significantly affect the facility's ability to meet performance objectives or may preclude defensible modeling and prediction of long term impacts] [Prefer land with slopes less than or equal to 15% and land which provides a stable foundation for engineered structures] [Prefer land which provides a more stable foundation for engineered containment structures]
2	**Exclude sites where the probable waste management area would have an average slope greater than 20%**	Exclude areas located where slopes greater than 15% exist on areas of the disposal site where disposal units may be located, as mapped on USGS 7.5 minute quads utilizing a scale of 1:24,000 with a contour interval of either 10 ft. or 20 ft or on county top-ographic maps that utilize a scale of 1:50,000 and a contour interval of 20 ft.			**Disposal is prohibited in areas with slopes greater than 15% subject to instability including, but not limited to, the geologic processes of mass wasting, slumping, landsliding and gully erosion**
3	Surfical materials at the site shall have high shear strengths and bearing capacities (Category A)				
4	Upland drainage areas shall have size, geometry, and surface characteristics such that surface runoff expected from a statistical 100 year precipitation event can be reliably channeled through the site by natural drainage patterns.				
5		Exclude sites located in areas where there is lime-stone or other predomi-nantly carbonate lithologic units which outcrop at the surface, occur within 50 ft. of the surface and are grea-ter than 5 ft. thick, have been identified as areas with a potential for subsi-dence or exhibit evidence of subsidence at the surface			
6	[All streams draining the site have mean annual discharge of less than thirty CFS (Category B)]				
7	[The site is located at least 1 mile from any river or stream with mean annual discharge exceeding 500 CFS and from any lake (Category B)]				

Siting Criteria 2a. Geological and Flood Hazards Continued (page C).

	North Carolina	New Jersey	Illinois	Maine
1	The site should not be placed where the earth is likely to be disturbed by natural events such as landslides or excessive erosion	The disposal site selection process shall avoid areas where geological process such as mass wasting, weathering, erosion, slumping, landsliding, or the development of karst precludes meeting performance objectives or precludes defensible modeling and prediction of the long term impact of such occurrence	Areas shall be avoided where surface geologic processes such as mass wasting, erosion, slumping, landsliding or weathering occur with such frequency and to such an extent that they would affect the ability of the disposal site to meet performance objectives or would preclude defensible modeling and prediction of long-term impacts	
2				Exclude areas with average slopes greater than 20%
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Siting Criteria 3. Hydrogeological Factors (page A).

	NRC	Michigan	Texas	New York	Nebraska
1	The disposal site must provide sufficient depth to the water table that groundwater intrusion, perennial or otherwise into the waste will not occur. In no case shall waste disposal be permitted in the zone of fluctuation of the water table	Exclude areas where the water table associated with geologic deposits or formations is not sufficiently low to prevent the intrusion of groundwater into the disposal unit or bottommost portions of the leak detection system	The site should be located so that there is sufficient depth to the water table to preclude groundwater intrusion, perennial or otherwise, into the waste	The disposal site must have sufficient depth to the water table that groundwater intrusion, perennial or otherwise, will not occur. Exception: If it can be conclusively shown that disposal site characteristics will result in molecular diffusion being the predominant means of radionuclide movement. In no case will the waste disposal unit be permitted in the zone of fluctuation of the water table	The disposal site shall provide sufficient depth to the water table that groundwater intrusion, perennial or otherwise into the waste will not occur. In no case will waste disposal be permitted in the zone of fluctuation of the water table.
2		Exclude areas where there is not 6 or more meters of soil with a maximum permeability of $1X10^{-6}$ cm/sec at all points below and lateral to the disposal unit and bottommost portions of the leak detection system or areas where there is less than 6 meters of relatively impervious soil providing equivalent environmental protection. This soil shall extend laterally a sufficient distance to assure that it cannot be circumvented by groundwater flow in 500 years		Site geology, soils and hydrogeology must have characteristics and properties which will retard the movement of radionuclides. Exclude areas located where existing mined openings and/or bore holes preclude the facility from meeting performance objectives	
3		Exclude areas where the average travel time of groundwater along any 100 foot flowpath from the water table beneath the bottom of the disposal unit is less than 100 years			
4					
5		Exclude areas where the average groundwater travel time from the water table beneath the bottom of the disposal unit to an aquifer is less than 500 years			
6		Exclude areas located over a designated sole source aquifer	The site shall not be located on the recharge zone of the major or minor aquifers of Texas	Exclude areas located above the Long Island aquifer, any public water supply aquifer, or a principal aquifer designated by the department	
7		Seek areas that do not overlie aquifers that produce potable water			

Siting Criteria 3. Hydrogeological Factors Continued (page B).

	Massachusetts	Pennsylvania	California	Vermont	Connecticut
1	[The minimum depth to the water table shall be at least 10 feet in the waste management area (Category A)] [The depth to the water table over the entire waste management area shall be at least 30 feet] **Exclude sites where the minimum depth to the water table is insufficient to prevent the intrusion of groundwater, perennial or otherwise, into the waste**	A disposal site shall be located in a hydrogeologic setting that provides sufficient separation from the groundwater so that water intrusion into disposal units, perennial or otherwise will not occur	Exclude areas where waste would contact groundwater Avoid areas with less than 100 ft. to groundwater.	Exclude sites where there is not sufficient depth to the water table to preclude groundwater intrusion, perennial or otherwise	Exclude land where the seasonal high water table under the active part of the facility would be less than 5 feet below the surface of the land or the base of the disposal units, whichever is deeper. [Prefer land where the seasonal high water table is deeper]. **Distance between the active parts of the proposed facility and any water supply well, water supply, surface water feature, or aquifer in use or planned as a water supply source except for the wells and surface water supply features of the proposed facility: 400 ft.**
2	[In those areas of the site where the water table extends above the bedrock surface, the average hydraulic conductivity in the saturated soils is at most 10^{-4} cm/sec. In those areas of the waste management area where the water table is below the bedrock surface, there is a minimum total thickness of (unsaturated) soil units of at least 10 ft. whose saturated hydraulic conductivity would be at most 10^{-4} cm/sec] **Exclude sites where the water table is below the bedrock surface and where between the bedrock and the bottom of the waste management unit there is less than a minimum total thickness of 10 feet of (unsaturated soil units (natural or placed) with a maximum saturated hydraulic conductivity of 1X10 $^{-4}$ cm/sec**	Exclude areas located where hydrologic conditions such as hydraulic conductivity or geologic features such as fractured bedrock occur at rates, frequency or extent that could adversely affect the isolation of waste or the ability to meet performance objectives	Avoid areas with less than 150 feet of soil thickness	The disposal site must retard, or be capable of being modified to retard, the movement of radionuclides	[Prefer land where natural characteristics, including, but not limited to, permeability and sorptive potential of the soil (subsurface materials) best retard the movement of radionuclides]
3	The average hydraulic gradient in the uppermost aquifer underlying the site shall be less than 0.01				
4					
5					
6	The waste management area shall not be located over the [recharge area] **aerial extent** of a sole source aquifer unless: (Category A) 1. There are no existing or potential groundwater supplies down-gradient of the site, and 2) There are sufficient existing or potential public water supplies to meet the projected needs of the area] **Exclude sites located within the Zone III of an existing public water supply with a maximum approved pump rate of 100,000 gpd or more**		The disposal site should not be located in areas where it would degrade groundwater quality	Exclude sites located within a watershed of Class A waters, within or adjacent to an aquifer protection area or a Class I or Class II aquifer, or where surface water quality standards could be reasonably expected to be violated	[Exclude land classified as an aquifer protection area] [Prefer land that minimizes the potential for impact to surface and groundwaters used as water supplies] [Exclude land with groundwater classified as GAA or with a goal of GAA] **Consider the potential effects of any facility on private and public water supplies**
7					

Siting Criteria 3. Hydrogeological Factors Continued (page C).

	North Carolina	New Jersey	Illinois	Maine
1	The highest level of the water table should be no closer than 7 feet from the bottom of the facility	The disposal site must be located such that groundwater intrusion into the waste can be prevented. In no case will the disposal units be located within the zone of fluctuation of the water table	The disposal site shall provide sufficient depth to the water table that groundwater intrusion, perennial or otherwise, into the waste will not occur. Exception: If it can be conclusively shown that disposal site characteristics will result in molecular diffusion being the predominant means of radionuclide movement and the rate of movement will result in the performance objectives being met. In no case will waste disposal be permitted in the zone of fluctuation of the water table	Exclude areas with shallow groundwater table (<2 ft) Favor lands with a deeper water table
2				Favor thick laterally extensive soils (glacial, till and marine clay) with low permeability and high retardation Exclude sites with anomalous zones of highly permeable soil or rock Avoid surfical deposits unlikely to provide effective barriers to groundwater movement: a) thin drift or bedrock b) stagnation moraine, end moraine, ribbed moraine Prefer sites likely to provide the most effective natural barriers to release of radionuclides off-site.
3				Exclude sand and gravel aquifers. Avoid bedrock structures and lithologies that may provide significant pathways for groundwater flow or present complex hydrologic conditions
4				Avoid areas with adverse hydrologic conditions (recharge, high gradients, and radial flow) associated with hilltops and ridgetops
5				
6	Areas are to be avoided that are the recharge areas of sole source aquifers or drinking water supply watersheds unless it can be demonstrated with reasonable assurance that the disposal site will be designed, constructed, operated, and closed without an unreasonable risk to an aquifer or drinking water supply			
7				

Siting Criteria 3a. Hydrogeological Factors (page A).

	NRC	Michigan	Texas	New York	Nebraska
1		Seek areas which do not include public water supply wells, well fields, high capacity production wells, and abandoned wells		Exclude areas where potential adverse effects on groundwater quality could result in contravention of water quality standards or an impairment of best intended usage	
2		Exclude areas located above an aquifer that is the primary source of drinking water for a municipality or county or for persons residing or doing business in the municipality or county where a candidate site is located			
3	The hydrogeologic unit used for disposal shall not discharge groundwater to the surface within the disposal site	Exclude areas located where the hydrogeology beneath the site discharges groundwater to the land surface within 3000 feet of the boundaries of the candidate site	Any groundwater discharge to the surface within the disposal site shall not originate within the hydrogeologic unit used for disposal	The regional groundwater flow system must provide a sufficiently long pathway and slow transit time from the land disposal facility to the discharge area to ensure that performance objectives are met The hydrogeologic unit on or within which waste is disposed must not discharge groundwater to the surface within the disposal site	The hydrogeologic unit used for disposal shall not discharge groundwater to the surface within the disposal site
4				Exclude areas where potential adverse affects on surface water quality could result in contravention of water quality standards or an impairment of best intended usage	

Siting Criteria 3a. Hydrogeological Factors Continued (page B).

	Massachusetts	Pennsylvania	California	Vermont	Connecticut
1	[The waste management area shall not be located within a Zone II area of an existing public water supply well or a potential public groundwater supply (Category A)] **Exclude sites within the Zone II of an existing water supply.**	Exclude sites located within 1/2 mile of a well or spring which is used as a public water supply	Avoid public water supply wells. Avoid well fields or high-capacity production wells	Exclude sites located within a watershed of a public water supply	[Avoid land above any subsurface water feature in use or planned (in a water company 50 year supply plan or in an area-wide supplement to a water supply plan that has been prepared and submitted to the Dept. Of Health Services by 7/1/90 but which has not been approved by the Dept.) as a water supply source]
2					
3	**Exclude sites located over a potential productive aquifer (PPA) which has been determined by DEP to be qualified for development as a public drinking water system prior to the issuance of the Draft Candidate Site Identification Report. Notwithstanding this exclusion, a site may be located within a PPA qualified for development where the site is proposed to be outside of the Zone II of any system and outside of the Zone III systems pumping 100,000 gpd or more** **Exclude sites located within a Zone of Contribution of an existing private groundwater source or non-community system unless the source/system is located on the parcel of land that is designated to be acquired pursuant to M.G.L. c.111H, s. 23(g) and is secured from any use other than uses related to the construction, operation, or environmental monitoring of the facility** **Exclude sites in which a hydrogeologic unit within the probable waste management unit discharges groundwater to the surface within the site**			The hydrogeologic unit used for disposal shall not discharge groundwater to the surface within the disposal unit	[Exclude land where the hydrogeologic unit that would be used for disposal would discharge groundwater to the surface within the disposal site] [Prefer land with hydrogeology that is not highly vulnerable]
4	[The waste management areas shall be located no closer than 1/2 mile upgradient from a surface drinking water supply as defined by groundwater flow or surface water drainage (Category B)] [The waste management area shall be at least 250 feet upgradient, as defined by groundwater flow or surface water drainage of any perennial watercourse that drains to a surface drinking water supply within one mile] **Exclude any site where the probable waste management area would be located within the watershed of a Class A public surface drinking water supply. Exclude any site where the probable waste management area would be located within any of the following areas of a Class B public surface drinking water supply; 400 feet from the 100-year flood plain elevation extending 1/2 mile upgradient from the supply intake and extending 200 feet downgradient from the supply in-take or the physical spillway, whichever downgradient distance is less**	Exclude sites located within 1/2 mile of either side of a stream or impoundment for a distance of 5 stream miles upstream or a surface water intake for a public water supply		Exclude areas located within 100 meters of a stream, river, lake or pond, within 200 meters of designated resource waters, or within distances found critical by site investigation	[Avoid any surface water feature in use or planned (in a water company 50 year water supply plan or an area-wide supplement to a water supply plan that has been prepared and submitted to the Dept. Of Health Services by 7/1/90, but which has not yet been approved by the Dept.) as a water supply source]

Siting Criteria 3a. Hydrogeological Factors Continued (page C).

	North Carolina	New Jersey	Illinois	Maine
1	Waste disposal shall not take place within 1000 feet of drinking water wells, except for on-site wells controlled by the licensee and used to supply water solely to the facility. **This minimum distance may be increased in any lateral direction when required by site-specific conditions** The site should not be near a main drinking water sources. Special attention should be given to the location of the site to avoid sole source aquifers and watersheds for public drinking water	The disposal site selection process shall avoid areas where the construction, operation, or closure of the facility could adversely impact the quality or quantity of presently available or projected public drinking water supplies. Specifically, the disposal site selection process shall avoid areas where maximum dose limits established by EPA 40CFR141 and NRC 10CFR61 could be exceeded	The site shall be located so as to minimize the possibility of radioactive releases into groundwaters utilized as public water supplies	Exclude primary recharge areas and water supply wells Avoid recharge areas of sand and gravel aquifers and bedrock wells used as community water supplies: a) granular soils contiguous with sand/gravel aquifers used as community water supplies b) watershed elements directly recharging sand/gravel aquifers or bedrock wells used as community water supplies Avoid recharge areas of aquifers having significant potential for future use as public water supplies: a) granular soils contiguous with high yield sand/gravel aquifers (>50 GPW) b) watershed elements directly recharging high yield sand and gravel aquifers and bedrock localities that provide well yields > 50 GPM Prefer sites with minimum potential for degrading water supplies
2				
3	Water should not come from the ground within the site	The hydrogeologic unit used for disposal shall not discharge groundwater to the surface within the disposal site	The hydrogeologic unit used for disposal shall not discharge groundwater to the land surface within the disposal site	
4				Avoid watersheds of great ponds Avoid lands within 100 feet of perennial streams and great ponds

Siting Criteria 3b. Hydrogeological Factors (page A).

	NRC	Michigan	Texas	New York	Nebraska
1	The disposal site must be generally well drained and free of areas of flooding and frequent ponding, upstream drainage areas must be minimized to decrease the amount of runoff which could erode or inundate waste disposal units	Exclude areas not free of ponding or incapable of being drained in a manner that ensures the integrity of the disposal unit	The site should be located so that drainage is minimal and easily manageable. This generally indicates an area with an existing grade of 5% or less	The surface contours and drainage systems of the site must be such that the area is well-drained and free of flooding and ponding	The disposal site shall be generally well drained and free of areas of flooding or frequent ponding, upstream drainage areas shall be minimal to decrease the amount of runoff which could erode or inundate waste disposal units
2		Exclude areas located within 10 miles of the Great Lakes			
3					
4	The disposal site shall be capable of being characterized, modeled, analyzed, and monitored	Seek areas with simple hydrogeologic systems that can be characterized, modeled, analyzed and monitored	The site should be capable of being characterized, modeled, analyzed, and monitored	Site hydrology, geologic formations, and groundwater flow systems must be capable of being characterized, modeled, analyzed, and monitored	The disposal site shall be capable of being characterized, modeled, analyzed, and monitored
5					
6				The present and projected geologic and hydrogeologic setting of the site including the effects of construction must be compatible with the waste disposal method	

Siting Criteria 3b. Hydrogeological Factors Continued (page B).

	Massachusetts	Pennsylvania	California	Vermont	Connecticut
1	Exclude areas which are not well-drained and free from ponding and frequent flooding	A disposal site shall be generally well drained and free of areas of flooding or frequent ponding	Exclude poorly drained locations Seek sites in areas of low intensity rainfall	The disposal sites must be generally well drained and free of areas of flooding and frequent ponding	[Exclude land that is not free of areas of flooding or frequent ponding resulting from poor drainage of surface waters] [Avoid land where the surface is generally not well drained] [Prefer land with a smaller upstream drainage area]
2			Avoid aqueducts and supply reservoirs		[Exclude major watercourses] [Prefer land that minimizes potential impacts on watercourses]
3			Avoid groundwater recharge areas		
4	[Seek areas] **Exclude areas not** capable of being characterized, modeled, and monitored with respect to geologic, hydrogeologic, [and environmental] **and groundwater flow** characteristics [important to waste isolation] **as reasonably necessary to demonstrate compliance with DPH performance objectives and those provisions of applicable state and federal regulations governing environmental monitoring**		Seek areas with simple hydrologic systems which can be readily monitored and modeled	The disposal site must be located in an area that is capable of being characterized, modeled, analyzed, and monitored	[Exclude land that is not capable of being characterized, modeled, analyzed and monitored to meet requirements of the NRC and the EPA] [Prefer land that is capable of being characterized, modeled, analyzed, and monitored to meet the requirements of the NRC and EPA] [Prefer land that does not have sufficiently high natural background radiation to significantly mask the environmental monitoring system]
5					
6					

Siting Criteria 3b. Hydrogeological Factors Continued (page C).

	North Carolina	New Jersey	Illinois	Maine
1	[The site should be easily drained of water with no chance of serious flooding by storms, hurricanes, river water or sea water]	The disposal site shall generally be well drained and free of areas of flooding or frequent ponding	The disposal site shall be generally well drained and free of areas of standing water or flooding or frequent ponding	Favor lands with good conditions for surface drainage and runoff
2				Exclude surface water bodies - rivers, streams, lakes Avoid lands within 1000 feet of the .20 foot elevation contour adjacent to the ocean shoreline
3				
4	[Ground conditions and water flows should be fully understood]	The hydrogeologic setting of the disposal site shall be such that groundwater flow can be characterized, modeled, analyzed, and monitored	The disposal site shall be capable of being characterized, modeled, analyzed, and monitored. At minimum such characterization must be able to: A) Delineate groundwater flow paths B) Estimate groundwater flow velocities C) Determine geotechnical properties sufficiently to support facility design At a minimum for site groundwater monitoring, disposal site operators must be able to: a) Assess the rate and direction of groundwater flow in the uppermost aquifer B) Determine background groundwater quality C) Promptly detect groundwater contamination	
5				
6				

Siting Criteria 4. Transportation (page A).

	NRC	Michigan	Texas	New York	Nebraska
1		Seek areas which minimize the risk of transportation accidents	The site should be located such that transportation problems are minimized	Existing highways and rail lines likely to be used as routes must be adequate or capable of being made adequate to meet state and federal laws and regulations and to minimize public risks from transportation accidents	
2		Seek areas which minimize the risks of exposures associated with transportation accidents			
3			The proposed site should be accessible. Rail or barge transportation is desirable		
4					
5					

Siting Criteria 4. Transportation Continued (page B).

	Massachusetts	Pennsylvania	California	Vermont	Connecticut
1	[Seek areas which are serviced by state or federal highways or other well maintained high quality roads that minimize the potential for accidents and traffic congestion. If such roads do not exist at the time of the site selection, land must be available and physical conditions must permit the development of such roads in connection with the project (Category A)] [The transportation requirements described above are already substantially met by existing roads (Category B)]		Avoid highways with high accident rates	To be established by rule: Mitigation or avoidance of harm from unanticipated releases and from transportation accidents	
2		A disposal site shall be located so that the roads connecting the site to an existing or limited access highway allow for safe transportation so that risks to the general population will be as low as reasonably achievable			[Prefer land for which there is less risk and potential impact of an accidental release of LLRW during transportation] **Consider the risk a waste facility at the site would pose to the local public health, safety and welfare, including the risk from an accidental release of low-level radioactive wastes during transportation to the facility or while at the facility, and the risks from water, air and land pollution and from fire and explosions**
3	[Seek areas within five miles of an interstate highway or connector or alternative preferred route designated by the Massachusetts State Routing Agency for highway route controlled shipments of radioactive materials (Category B)		Seek sites close to divided highways, sites that require minor road improvements and/or construction, and sites with available railroad access		
4	Either: 1) The site is located within 50 miles of the centroid of the low-level radioactive waste generators in the Commonwealth, or 2) the total number of calculated curie-miles associated with annual shipments from the producers to the site by the most direct routes consistent with state and USDOT regulations is no more than 20% higher than if the site were located at the centroid (Category B)]]				[Prefer land that is closer to concentrations of LLRW generators] **Consider the economic feasibility of a waste facility at the site, including the proximity of the site to concentrations of generators of low-level radioactive waste**
5			Avoid roads with frequent hazardous conditions, two lane roads passing through heavily populated areas, and sites requiring bridge improvements		

Siting Criteria 4. Transportation Continued (page C).

	North Carolina	New Jersey	Illinois	Maine
1		The disposal site selection process shall consider the potential impacts of the transportation of LLRW to the facility	The disposal site shall be located so as to minimize impact on traffic flows	Prefer site locations with minimum levels of transportation risk
2				
3				
4	[The site should be convenient to major highways that are accessible to the principal generators of the region]			
5				

Siting Criteria 5. Meteorology.

	NRC	Michigan	Texas	New York	Nebraska
1	Thorough evaluation of existing conditions.	Seek areas with simple meteorological systems that can be characterized, modeled, analyzed, and monitored	The site shall not be located in an area where severe meteorological conditions such as tornadoes, excessive winds, or thunderstorms occur with sufficient frequency as to adversely effect site performance		

	Massachusetts	Pennsylvania	California	Vermont	Connecticut
1		A disposal site shall be located so that adverse climatic and meteorologic conditions will not affect the ability of the disposal site to meet performance objectives	Avoid sites near Class I Air Quality Management Areas Avoid sites with frequent high surface winds Avoid sites located upwind of military installations (China Lake Naval Weapons Testing Center and Edwards Air Force Base) for which visibility is important to operations		[Prefer land where a facility would have fewer adverse affects on air purity and would be in less conflict with state policies on air purity]

	North Carolina	New Jersey	Illinois	Maine
1		In addition to surface water and groundwater the disposal site selection process shall consider other potential transport mechanisms for radionuclides, including biotic and airborne. The disposal site shall be located such that maximum dose limits established by NRC 10CFR61 will not be exceeded		Prefer sites with minimum potential exposure to hazards of weather and climate Prefer sites where development of the facility will have the lowest potential for degrading air quality

Siting Criteria 6. Environmental and Resource Factors (page A).

	NRC	Michigan	Texas	New York	Nebraska
1	Waste disposal shall not take place in an area designated as a wetland by executive order 11968	Exclude areas containing wetlands	Disposal sites shall not be located in wetland areas	Exclude areas containing wetlands including freshwater wetlands and tidal wetlands	
2	Waste disposal shall not take place in a coastal high hazard area	Exclude coastal high risk areas as defined in the Shorelands Protection Act	Disposal sites should not be located in a coastal high hazard zone	Exclude areas defined by statute as coastal erosion hazard areas	
3	Areas shall be avoided having known natural resources which, if exploited, would result in failure to meet performance objectives in 10CFR61 Subpart C	Seek areas where natural resources do not exist on or near to the candidate site	Avoid areas which have economically significant, recoverable natural resources	Exclude sites located in an area where past, present, or future exploration of natural resources precludes the facility from meeting performance objectives	Avoid areas having known natural resources, which, if exploited, would result in failure of the site to meet performance objectives
4		Seek areas which do not cause visual intrusion on designated scenic highways			
5		Seek areas which will not require that prime farmland be removed from agricultural production		Seek areas with minimal impacts on agricultural lands, operations, and districts. Exclude areas containing more that 5 acres of active agricultural land classified in soil groups 1-4 by the NY state land classification system	

Siting Criteria 6. Environmental and Resource Factors Continued (page B).

	Massachusetts	Pennsylvania	California	Vermont	Connecticut
1	The waste management area shall be located [250] **100** feet from any wetland (Category A)	Exclude areas located within 1/2 mile of an existing important wetland (as defined)	Exclude sites located in a wetland	Exclude sites located within 100 meters of a wetland	[Exclude land that is classified as a wetland under the Federal Clean Water Act] [Prefer land that is further from land that is classified as a wetland under federal or state law]
2	Exclude areas located in coastal high hazard zones (Category A)		Exclude sites located in a coastal high hazard area	Exclude sites located in a coastal high hazard zone	Exclude land that is inside the boundary of a coastal area subject to storm surge [Prefer land that is further away from coastal areas subject to storm surge (coastal high-hazard areas)]
3	[Exclude areas containing economically recoverable mineral resources that are unique to the local region or to the state either because of its high quality, economic superiority or quantity, unless the exploitation of that resource is compatible with the operation of the facility (Category A)]	Exclude sites located where exploration or exploitation of natural resources, such as hydrocarbons, industrial minerals, metallic ores and mineral fuels located on the site or in adjacent areas could affect ability to meet performance objectives Exclude sites located in areas over active or inactive oil and gas wells or gas storage areas or in areas over active or inactive mines that are identified and substantiated by public record	Exclude areas of existing or potential economic mineral resource development (e.g., active mining)	Exclude locations with known areas of natural resources that, if exploited, could preclude the facility from meeting performance objectives	[Exclude land that has known natural resources which, if exploited, would result in failure to meet the NRC's performance objectives] [Prefer land that is farther away from land that has known natural resources which, if exploited, would result in failure to meet the NRC's performance objectives]
4			Avoid sites adjacent to designated scenic highways		**Consider the potential compliance of any waste facility constructed at the site with federal and state laws and regulations, including, but not limited to, environmental laws and regulations**
5	**Exclude sites located on prime agricultural land based on soil classification established by the U.S. Soil Conservation Services or on land designated as an agricultural incentive area on or before 12/31/92**	Exclude areas located on agricultural land established under the Agricultural Area Security Law or Class I agricultural land as defined by the US Soil Conservation Service	Avoid areas of existing cultivated agriculture or development areas		[Avoid land that is agricultural land for which the Commissioner of Agriculture has acquired the development rights]. [Prefer land that is farther away from agricultural land which the Commissioner of Agriculture has acquired the development rights]. [Prefer land that is not agricultural land for which a municipality has acquired the development rights as of January 1, 1989]. [Prefer land where a facility would have less of a potential adverse affect on agricultural resources]. [Prefer land that contains less than 25 acres of prime farmland in aggregate] **Consider the adverse effect of any waste facility at the site on agricultural and natural resources and the availability of resources for mitigating or eliminating such adverse effects by stipulations, conditions and requirements for the facility's design and operations**

Siting Criteria 6. Environmental and Resource Factors Continued (page C).

	North Carolina	New Jersey	Illinois	Maine
1		The disposal unit shall not be located in a wetland	Exclude areas containing wetlands	Exclude wetlands
2		The disposal unit shall not be located in a coastal high hazard area	Exclude sites located in a coastal high hazard area	Exclude coastal hazard areas
3	[The place where the site is located should not have known significant natural resources such as water, oil, coal, or other minerals]	The disposal site selection process shall attempt to avoid areas of known natural resources, which if exploited, would result in failure to meet performance objectives	Areas shall be avoided having known natural resources which, if exploited, would result in failure to meet performance objectives	Avoid lands containing potentially exploited or potentially exploitable mineral resources
4				Avoid locations within the direct viewshed of scenic and cultural resources subject to exclusion factors Prefer sites having minimum potential adverse visual or noise impact on the surrounding area
5			Seek areas which will not require that prime farmland be removed from agricultural production (consistent with the Farmlands Preservation Act)	Avoid land classified as prime farmland based on SCS Soil Classification

Siting Criteria 6a. Environmental and Resource Factors (page A).

	NRC	Michigan	Texas	New York	Nebraska
1		Exclude areas where siting will be inconsistent with federal and state laws protecting environmentally sensitive areas, cultural and heritage values, and areas dedicated as national and state parks and wilderness preservation areas	The site should not be located within or adjacent to state designated historic sites, a national or state park or monument, a wildlife management area, an area of archeological significance or an area affecting the habitat of endangered or protected species	Exclude areas located on lands owned by the federal, state, or municipal governments, where alienation or use of such land is statutorily prohibited, including but not limited to property which is a national wildlife refuge, state wildlife management and/or fishing area, migratory bird reservation, reforestation area, wilderness preservation area, or wetland acquired or restored with state moneys Exclude areas listed, nominated or eligible for listing as a historic place, areas subject to the national wild and scenic rivers system, areas within the Adirondack or Catskill Parks system, or any national or state park or any municipal park established after December 31, 1987, reservations of Indian tribes or nations or on lands that are not subject to the laws and regulations of the state of New York, including lands owned by the federal government Exclude areas defined by statute as the critical habitat for any endangered or threatened species or species of special concern	

Siting Criteria 6a. Environmental and Resource Factors Continued (page B).

Massachusetts	Pennsylvania	California	Vermont	Connecticut
1 Exclude areas which adversely impact any national park, monument, lake shore, habitat, or endangered species or area protected by the Wilderness Act, the Wild and Scenic Rivers Act, the Fish and Wildlife Coordination Act, or the National Historic Preservation Act (Category A) [Exclude areas which adversely impact any state or local protected land, facility, or resource unless such impact can be mitigated to the satisfaction of the agency responsible for overseeing the land or facility (Category A)] [Exclude areas which: 1) Have an adverse impact on endangered, threatened, or special concern species listed by the state, or 2) Have an adverse impact on ecologically significant natural communities as designated by the state (Category A)] Exclude sites located in any area of critical environmental concern as designated by the Office of Environmental Affairs (Category A) The site is located at least 1/2 mi. from any lands specifically protected under the Wilderness Protection Act, the Wild and Scenic Rivers Act, the Fish and Wildlife Act, and the National Historic Preservation Act (Category B) [The site is located at least 1/2 mile from any lands or facilities of the following types: state parks, state reservations, state campgrounds, and state historical sites and monuments] **Exclude sites located in scenic and recreational rivers and streams of the Commonwealth, as designated by state law**	A disposal site shall be located so that resources, such as those protected by law, those suitable for human consumption and those culturally or historically unique, can be protected during siting, design, construction, operation, closure, decommissioning, and long term care Exclude areas located within boundaries of a national park system, national forest, natural landmark designated by the National Park Service, national wildlife refuge, national fish hatchery, national wild and scenic river including study rivers, national system of trails, national wilderness preservation, exceptional value watershed, historic site on the National Register of Historic Places, state, county, or municipal park system, land owned by the Historical and Museum Commission, land protected by the Wild and Scenic Rivers program, designated natural and wild areas, or in the boundaries of state forest and state game land unless the respective administering agency has been given authority by statute or ordinance to allow siting and operation of the disposal facility	Exclude sites located in the East Mojave National Scenic Area, National monument and state park systems, military reservations, private lands held for preservation and nature conservancies Exclude critical habitats of federally listed endangered plant or animal species. Exclude areas designated or recommended for the National Historic Register Avoid sensitive native plant communities, important habitat features (water locations, migratory routes), and identified scientific study areas Avoid wilderness study areas, sites close to proposed state prison development, designated off-road vehicle use areas, designated campgrounds, popular rock-hounding areas, popular hiking areas, and popular hunting grounds Avoid identified historic areas, native American resource areas, native American hunting and gathering areas, and national park service scenic resources	To be established by rule: The proximity of the disposal site to schools, historical sites, wilderness areas, parks (municipal, state or national), state or wildlife refuges or management areas, military sites or unique cultural areas and the potential for adverse effects on rare or endangered species	[Exclude land that is a national park, monument, scenic river wilderness area, state park, state forest, critical habitat area for federal or state endangered species, a federal threatened species habitat, a federal wildlife refuge, an archeological or historic place or a registered historic site or landmark]. [Exclude land that is a protected river corridor designated by the Department of Environmental Protection, is inside the Lower Connecticut River Conservation Zone, inside the Upper Connecticut Conservation Zone, a historic district established as of 1/1/89, or is native American reservation land held in trust by the state]. [Avoid land that is an ancient burial place, land that is a critical habitat area for state threatened species, existing preserved open space land and preservation area land as defined in the 1987-1992 state policies plan, land that is major open space land acquired by a municipality as of 1/1/89, or land that is major open space land in which a municipality has acquired an easement, interest or right to limit the future use of or otherwise conserve the open space land as of 1/1/89]. [Prefer land that is farther away from national parks, monuments, scenic rivers, wilderness areas, state parks and forests, critical habitat areas for endangered species, federal wildlife refuges, archeological and historic places, historic sites and landmarks, ancient burial places, protected river corridors designated by the DEP, the Lower Connecticut River Conservation Zone, the Upper Connecticut River Conservation Zone and native American reservation lands held in trust by the state]. [Prefer land that is not a cemetery, land that is farther away from municipal forests established as of 1/1/89, existing preserved open space land and preservation land as defined in the 1987-1992 state policies plan, major open space land acquired by a municipality as of 1/1/89 or in which a municipality has acquired, as of 1/1/89, an easement, interest, right to limit future interest, or right to limit future use, land that as of 1/1/89 is not restricted to conservation or recreation use in accordance with an established open space program, and land that as of 1/1/89 has not been designated as a historical district]. [Prefer land where a facility would have fewer effects on natural resources, the natural environment, and the ecological balance and would be in less conflict with state policies on the natural environment and the ecological balance]. [Prefer land where a facility would have fewer adverse effects on scenic and historic values and would be less in conflict with state policies on scenic and historic values]. [Prefer land that is more consistent with applicable goals and policies of the state's Coastal Management Act and that minimizes adverse impacts on coastal resources and future water-dependent development activities]. **Waste disposal is prohibited in critical habitat areas for federal and state endangered species and state parks and forests and registered historic sites and landmarks**

Siting Criteria 6a. Environmental and Resource Factors Continued (page C).

North Carolina	New Jersey	Illinois	Maine
1 [Prospective sites should be chosen with all of the requirements of the N. Carolina Environmental Policy Act under consideration. The disposal site should not be located so as to interfere with an area that is a breeding ground, nurturing area, or special habitat for rare, threatened or endangered species of animals and plants] [The site should not be close enough to affect the use of recreational or cultural areas, including oceans, lakes, rivers, national, state or community parks, dedicated wilderness areas, national, state or local monuments and historic sites, Indian burial grounds, churches, cemeteries, athletic stadiums, golf courses, and racetracks] [If possible, suitable land belonging to the federal or state government should be used for the site, excluding designated national, state, and community park lands. The facility should not be placed on a military post However, the existence of large land holdings by utilities and other industries should also be identified, with the possibility of acquisition by the state] [The authority will not deliberately seek out forest land for the use of the site. However, because of the large amount of forested land in the state, the authority will not deliberately exclude forest land from consideration]	The disposal site shall not be placed within federally protected lands set aside for the preservation of natural and cultural resources, specifically, the disposal site shall not be located within national parks, national forests, national wildlife refuge areas, federally designated wild and scenic rivers, wilderness areas or certain wetlands, national recreation areas, and the Pinelands National Reserve The disposal site shall not be placed within state protected lands set aside for the preservation of natural and cultural resources, specifically, the disposal site shall not be located within the Delaware and Raritan Canal State Park, Hackensack Meadowlands District, State Pinelands, state designated natural areas, and state designated wild and scenic rivers The site selection process shall attempt to avoid areas that are meaningful to people because of historic, cultural, religious, ethnic, or racial heritage, and known habitat areas for rare, threatened, or endangered species Consider all applicable federal and state regulations, statutes, and laws that refer to specific land areas or land used within the state of New Jersey which could impact on the feasibility of the siting of the LLRW disposal facility	Exclude areas where siting will be inconsistent with federal and state laws protecting environmentally sensitive areas, cultural and heritage values, and areas dedicated as national and state parks and wilderness preservation areas	Exclude Maine DPW wildlife management areas, federal or state sanctuaries, refuges, or preserves, habitat of threatened and endangered species, and state designated deer wintering areas, critical areas established by the Maine State Planning Office, unusual natural areas or coastal heritage areas, protection subdistricts designated by Maine LURC, lands above 2700 ft. elevation, the coastal barrier resource system, coastal sand dunes and wetlands, park and wilderness lands administered by the federal government and park and wilderness lands owned and administered by the state of Maine, including state parks, public reserved lands, and lands acquired using Land for Maine's Future funds, lands protected as nation wild and scenic rivers or as state designated outstanding river segments, historic places and archeological sites and Indian Trust lands (unless volunteered) Avoid lands in public or private ownership that are managed entirely for conservation or recreation and are within 1000 feet of excluded protected natural areas and other non-excluded lands managed entirely for conservation or recreation Prefer sites having minimum potential impact on terrestrial ecosystems

Siting Criteria 7. Economic and Social Factors (page A).

	NRC	Michigan	Texas	New York	Nebraska
1		Seek areas which are not included in formally proposed or approved development plans as of January 1, 1988			
2		If all other criteria are met, give preference to areas near communities desiring the facility			
3					
4			The site should preferably be located on existing state-owned land to minimize site acquisition problems and cost	The site must be located on real property to which the state of New York can obtain title in fee or any interest therein, as may be necessary	
5			A site shall not be located within 20 miles of a Corps of Engineers project		
6				The site must not be located at the Western New York Nuclear Service Center in West Valley New York	
7					

Siting Criteria 7. Economic and Social Factors Continued (page B).

	Massachusetts	Pennsylvania	California	Vermont	Connecticut
1			Seek compatibility with county general plans		Prefer land where a facility would be more consistent with the state plan of conservation and development, and with local and regional land use plans and regulations
2			Seek areas near communities desiring the economic benefits of the facility		
3					
4	**Exclude sites to which the Commonwealth cannot obtain title**		Seek areas within designated utility corridors and lands classified as BLM Class M lands		Prefer land where it would cost less to acquire a site and to construct, operate and close a LLRW disposal facility
5					
6					
7	[Seek sites located outside the following zones for both active and planned facilities, but not abandoned facilities: 1) within 1 mile from any airport runway 2) within 1 mile form any underground mine, surface mine or quarry that extends at least 30 ft. below the natural water table 3) within 1 mile from any dam or artificial embankment that causes the height of a waterway or surface water body to differ from its natural level by at least 30 ft. 4) within 1/2 mile from any single aboveground storage tank regularly used for the storage of flammable liquids and having a capacity of at least 500,000 gallons, or from any aboveground storage tank or vessel for liquefied natural gas or liquefied petroleum gas and having a capacity of at least 25,000 gallons (Category A) Aside from the above listed conditions, ongoing and reasonable foreseeable activities within 5 mi. of the site shall be of a nature that they do not pose significant potential either for modifying the site's characteristics so as to violate a Category A condition or to change unfavorably the site's rating with respect to a Category B condition, or lead to facility damage or direct release of radioactive material through a credible accident event (Category A)]				

Siting Criteria 7. Economic and Social Factors Continued (page C).

	North Carolina	New Jersey	Illinois	Maine
1				Exclude developed lands and lands approved for future development Prefer sites where development and operation of the LLRW facility will have minimum impact on present and future land use
2				Prefer sites with potentially fewer land acquisition and public acceptance factors
3				Prefer sites having minimum adverse socio-economic impacts
4				Prefer sites where the LLRW facility can be developed, operated and monitored at the lowest cost
5				
6				
7				

Siting Criteria 7a. Economic and Social Factors (page A).

	NRC	Michigan	Texas	New York	Nebraska
1					
2				The site must be capable of being licensed and permitted under all applicable state and federal laws	
3				The primary emphasis in site suitability must be given to isolation of wastes, a matter having long-term impacts, and to disposal site features that ensure that performance objectives are met as opposed to short-term convenience or benefits	
4				Any site to be used for disposal of mixed LLRW and hazardous waste must be capable of meeting provisions of applicable law	
5					
6					
7					
8					
9					
10					
11					

Siting Criteria 7a. Economic and Social Factors Continued (page B).

	Massachusetts	Pennsylvania	California	Vermont	Connecticut
1	[Exclude areas located within 1/2 mile from elementary or secondary schools, bedded health care facilities, or other similar facilities in which the young or the elderly are likely to congregate frequently and in large numbers (Category A)] **Exclude sites where the probable waste management area would be located in proximity to sensitive population locations as a result of which it is reasonably likely that the site will not be able to meet the DPH performance objectives or the exposure to radiation or toxic materials, if mixed waste is to be accepted at the site, which a member of the affective sensitive population is reasonably likely to receive in the event of a release of radiation or hazardous waste from the site would result in a significantly higher than normal risk of adverse effect on the health of the sensitive population**				Prefer land where a facility would have less effect on local public facilities and services **The applicant shall identify in its application all existing and presently planned schools, hospitals, nursing homes and occupied dwellings within 2 miles of all active parts of the proposed facility. The applicant shall demonstrate that the health and safety of persons utilizing such structures will not be jeopardized by the siting of the proposed facility**
2					
3					
4					
5			Seek sites close to existing available labor forces		
6					Prefer land where there is less risk of and potential impact from an accidental release of LLRW from a fire or an explosion at a facility
7					Prefer land where construction and operation of a facility would have less adverse economic impact
8					
9					
10	**Exclude sites that are not reasonably likely to meet DPH performance objectives based on a performance assessment that, at a minimum, incorporates the facility design standards of probable suitable technologies set forth in 105 CFR 120.815**				
11					

Siting Criteria 7a. Economic and Social Factors Continued (page C).

	North Carolina	New Jersey	Illinois	Maine
1				Prefer sites most amenable to establishing a baseline for monitoring of health effects in the local population
2				
3				
4				
5				Prefer sites in proximity to existing community services that would support construction, operation, and maintenance of the facility
6				
7				
8				Prefer sites most amenable to monitoring of potential radiation release from the facility
9				
10				Prefer sites with characteristics most compatible with the range of possible disposal technologies (or with the preferred technology once identified)
11				Exclude land within 1 mile of state and international boundaries

Siting Criteria 8. Site Size and Special Limits (page A).

	NRC	Michigan	Texas	New York	Nebraska
1		Exclude areas not sufficiently large to assure an isolation distance of 3000 feet or more between the disposal unit and adjacent property lines		The site must include a buffer zone of sufficient extent to contain a monitoring system to allow for any necessary remediation activities, to enable the licensee to maintain site security, to contribute to a desirable site appearance, and to meet performance objectives The site must be of sufficient size to ensure that performance objectives contained in 10CFR61 Subpart C can be met	
2					
3					

Siting Criteria 8. Site Size and Special Limits (page B).

	Massachusetts	Pennsylvania	California	Vermont	Connecticut
1	The site shall be large enough to accommodate waste volumes projected by the board and to provide an additional [500 foot] buffer zone separating the waste management area from abutting parcels of land (Category A)			The disposal site must be of sufficient size to allow the satisfaction of the performance objectives	[Exclude land that cannot accommodate a 160 acre active part of a facility and still contain no exclusionary criteria. Avoid land that cannot accommodate a 160 acre disposal site (active part, plus the area inside the security fence, plus the buffer zone) and still contain no exclusionary criteria. Prefer land that can accommodate a 250 acre disposal site and still contain no exclusionary criteria] **100 ft. distance between the active parts of the proposed facility and a security fence. 300 ft. distance between the security fence and all other land uses for the purpose of providing limited access and a buffer for monitoring**
2	[Land abutting the site for a distance of 1/2 mi. downgradient (considering groundwater flows) from the waste management area is controlled by institutional mechanisms]				
3				Exclude areas located above 2500 ft. in elevation	

Siting Criteria 8. Site Size and Special Limits (page C).

	North Carolina	New Jersey	Illinois	Maine
1				
2				
3				Exclude areas located above 2700 ft. in elevation